PB84-145937

EPA Evaluation of the VCD Supplemental Gaseous Fuel Delivery System under Section 511 of the Motor Vehicle Information and Cost Savings Act

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Ann Arbor, MI

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EPA Evaluation of the VCD Supplemental Gaseous Fuel Delivery System Under Section 511 of the Motor Vehicle Information and Cost Savings Act

by

Edward Anthony Barth

September, 1983

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Edward Anthony Barth

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16. ABSTRACT

This report announces the conclusions of the Environmental Protection Agency (EPA) evaluation of the "VCD Supplemental Gaseous Fuel Delivery System" under the provisions of Section 511 of the Motor Vehicle Information and Cost Savings Act.

The evaluation of the "VCD Supplemental Gaseous Fuel Delivery System" was conducted on the application of the manufacturer. The device is designed to operate the engine of a vehicle on a mixture of gasoline and propane. The device consists of a gaseous fuel metering and control unit, a modified carburetor and associated electrical and plumbing components. It functions by replacing some of the gasoline with propane under certain operating conditions. The device causes the ~~engine~~ engine to idle on propane, cruise on gasoline, and accelerate on a mixture of the two fuels. This is claimed to be more fuel efficient. This combination of improvements in fuel efficency and fuel substitution is claimed to save both fuel and money.

EPA fully considered all of the information submitted by the applicant. The evaluation of the "VCD Supplemental Gaseous Fuel Delivery System" was based on that information and EPA's engineering judgment. The device did substitute propane for some of the gasoline. Although the substitution of propane for gasoline has the potential to affect fuel economy, emissions and operating costs, neither the data submitted by the applicant nor technical analysis showed an economic or fuel economy

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Automobiles Fuel Consumption Exhaust Emissions Propane Tests	Fuel Economy Gas Saving Device	

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benefit. In fact, emission levels of HC and CO were found to increase substantially. Thus, in the absence of positive test data, EPA has no reason to support the claims made for the device or to continue the evaluation on its own.

EPA Evaluation of the VCD Supplemental Gaseous Fuel Delivery System Under Section 511 of the Motor Vehicle Information and Cost Savings Act

The Motor Vehicle Information and Cost Savings Act requires that EPA evaluate fuel economy retrofit devices and publish a summary of each evaluation in the Federal Register.

EPA evaluations are originated upon the application of any manufacturer of a retrofit device, upon the request of the Federal Trade Commission, or upon the motion of the EPA Administrator. These studies are designed to determine whether the retrofit device increases fuel economy and to determine whether the representations made with respect to the device are accurate. The results of such studies are set forth in a series of reports, of which this is one.

The evaluation of the "VCD Supplemental Gaseous Fuel Delivery System" was conducted on the application of the manufacturer. The device is designed to operate the engine of a vehicle on a mixture of gasoline and propane. The device consists of a gaseous fuel metering and control unit, a modified carburetor and associated electrical and plumbing components. It functions by replacing some of the gasoline with propane under certain operating conditions. The device causes the engine to idle on propane, cruise on gasoline, and accelerate on a mixture of the two fuels. This is claimed to be more fuel efficient. This combination of improvements in fuel efficency and fuel substitution is claimed to save both fuel and money.

1. Title:

   Application for Evaluation of VCD Supplemental Gaseous Fuel Delivery System Under Section 511 of the Motor Vehicle Information and Cost Savings Act

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The information contained in sections two through five which follow, was supplied by the applicant.

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2. Identification Information:

   a. Marketing Identification of the Product:

      VCD Supplemental Gaseous Fuel Delivery System

b. **Inventor and Patent Protection:**

(1) Inventor

Scott J. Venning
617 S. Busse Road
Mt. Prospect, Illinois 60056

(2) Patent

"Copy of patent and pertaining data attached." (Attachment A)

c. **Applicant:**

(1) VCD Fuel Systems
617 S. Busse Road
Mt. Prospect, Illinois 60056

(2) Scott Venning is authorized to represent VCD Fuel Systems in communication with EPA.

d. **Manufacturer of the Product:**

(1) VCD Fuel Systems
617 S. Busse Road
Mt. Prospect, Illinois 60056

(2) Principals

Scott Venning
617 S. Busse Road
Mt. Prospect, Illinois 60056

Anthony Christian
2832 NE 36th Street
Ft. Lauderdale, Florida 33308

Ronald Dadario
1219 SE 11th Ave.
Deerfield Beach, Florida 33441

3. **Description of Product:**

a. **Purpose:**

"To conserve fuel by supplementing gasoline with propane at advantageous times."

"The purpose of the device is to save fuel and money. Through testing we have established that idling with propane is more economical than gasoline and cruising with gasoline is more economical than propane. With the combination of idling on propane and cruising with gasoline, we have arrived with a considerable savings of fuel and money.

"Up until now, all propane converted vehicles used only propane and had no fuel or money savings, only availability to an alternative fuel when gasoline is unavailable or in shortage. Using propane only has the disadvantage of a 20% power loss.

"The VCD System also accelerates on gasoline and propane. Together, this [gives] you a leaner power circuit because the slight amount of propane used helps as does octane in fuel. We have included test results that we have performed. We feel that this system will be beneficial to the energy problem and save the public money." Attachment E.

b. Applicability:

"This system is applicable to all gasoline internal combustion engines. Test data has been compiled on the vehicles listed below:

1980-1981 GM Chevrolet	229 V6 Engine
Monte Carlo - Chev	2 BBL Rochester Carb.
Malibu - Chev	Automatic Transmission
Cutlass - Olds	H.E.I. Ignition

"This engine is randomly used in other GM vehicles such as Oldsmobile and Buick. To identify the 229 V6 Chev Engine, the 5th digit in the serial number is "K" for 1980-1981 models.

c. Theory of Operation:

"Basic Function; idles on propane, cruises on gasoline, accelerates on propane and gasoline (See Drawings Attached)." Attachment B, Figures 1 through 8.

d. Construction and Operation:

"See drawings attached", Attachment B, Figures 1 through 8.

(1) Description of Invention:

"(Fig. 7) System to be used with gaseous fuels such as propane, methane, natural gas or similar fuels. Propane, for example, starts in pressure tank (#10), passes thru shutoff (#8), thru regulator (#9), into metering unit (#12). On idling requirements, metering unit allows propane to be injected into carburetor (#1). On cruising or light acceleration, unit shuts off propane and carburetor relies on gasoline only. On acceleration, metering unit (acting as a power valve) enrichens mixture by injecting propane along with fuel.

(2) Description of Major Components of the VCD Device:

The detailed descriptions of the metering unit, idle switch, modified carburetor and system variations are given in Attachment B.

"This system is not intended for aftermarket installations for the public. The only form in consideration is to develop systems for fleet vehicles where the system can be designed and installed by trained personnel. This should enable us to omit general operating instructions and rely on instructions and descriptions as in format heading 'Description of Device.'"

e. Specific Claims for the Product:

The "Purpose of the device ... is to save fuel and money." Attachment E.

f. Cost And Marketing Information:

"This system is not intended for aftermarket installations for the public. The only form in consideration is to develop systems for fleet vehicles ..."

4. Product Installation, Operation, Safety and Maintenance:

a. Installation - Instructions, Equipment, and Skills Required:

"Parts List: Pressure Tank
Regulator
Shutoff
Hose
Clamps
Metering Unit
Modified Carb.
Wiring Diagram

"Installation: Basic Hand tools

1. Mount propane tank in trunk.
2. Run propane hose under vehicle into engine compartment.

3. Mount metering unit on firewall and connect propane hose to inlet on metering unit.
4. Remove existing carb and install modified carb.
5. Connect vacuum hose on metering unit marked P.V. to a ported vacuum source. Connect vacuum hose marked M.V. to a manifold vacuum source.
6. Connect wires as on wiring diagram.
7. Open pressure tank shutoff and adjust regulator to 1-1/2 - 2 lbs.
8. All units come pre-set. If idle speed needs adjusting, unloosen locknut on metering unit and adjust rod accordingly."

b. Operation:

The device modifies the vehicle to ... "idle on propane, cruise on gasoline, accelerate on gasoline and propane."

c. Effects on Vehicle Safety:

"This system is wired into an oil pressure switch; therefore, if the engine stopped running and was not noticed, the propane would automatically shut off as the oil pressure drops to zero.

"Vehicles that have been using propane only, have proven [it] to be a safe fuel for automobiles."

d. Maintenance:

"Maintenance on engines equipped with this system should follow regular engine maintenance procedures.

"There is no preventative maintenance on this system. With every refill of propane, check to see if the pressure is 1-1/2 - 2 lbs."

5. Effects on Emissions and Fuel Economy:

a. Unregulated Emissions:

"With propane being a cleaner fuel to burn, this system will operate within or better than EPA requirements."

b. Regulated Emissions and Fuel Economy:

The fuel economy test results provided are given in Attachments E and N.

The following Sections are EPA's analysis and conclusions for the device.

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6. Analysis

a. Identification Information:

Marketing Identification:

VCD Supplemental Gaseous Fuel Delivery System was identified as the marketing name for the product. However, the device is vehicle and engine specific and is now available for only one engine (GM 229 V-6). The three basic variations of the system (VCD Supplemental Gaseous Fuel Delivery System, types V-1, V-2, and V-3) were not evaluated. Attachments D and F.

b. Description:

(1) As stated in Section 3a, the primary purpose of the VCD device is to conserve gasoline and thereby save fuel and money. This is in agreement with the theory of operation and design of the device.

(2) In Section 3b, the theory of the device was claimed to be applicable to all gasoline internal combustion engines. It was clarified that, at present, the device was not applicable to engines with feedback carburetors or fuel injection (Attachments D and F).

(3) The theory of operation given in Section 3c is judged to be in agreement with the description of the device (Section 3d) and is able to be designed to function as described.

(4) The description of the device given in Section 3d is judged to be adequate for the design being evaluated as well as the several variations (V-1, V-2, and V-3).

(5) The device is claimed to save both fuel and money. These claims are in agreement with the purpose, theory of operation, and construction of the device. However, no specific numerical improvements were claimed. In response to our request for the specific claims to be made for the device, the applicant stated that the device would:

   (a) "Reduce the cost of fuel and use of energy by 30% while idling."

   (b) "Reduce the cost of fuel and use of energy by between 14 and 23% in normal vehicle operation."

   (c) "Achieve these savings without a loss of power" (Attachments D, F, and G).

combustion process and emissions. However, since only a small amount of propane is used, it is judged that this change is unlikely to appreciably affect unregulated emissions.

(2) Regulated Emissions and Fuel Economy:

EPA assisted the applicant in developing test plans for testing the device at an independent lab (Attachments G, H, I, J, K, L, and M). The applicant tested the device in accordance with the Federal Test Procedure and the Highway Fuel Economy Test and submitted the data (Attachment N).*

The applicant stated in his letter providing these data that there were numerous driveability problems when the device was tested but that he felt that these problems could be overcome through additional work (Attachment N). Also, he expected to retest in the future. However, since retesting was not done within a reasonable period and since these were the best test data available, EPA was obligated to complete the evaluation of the device with the available information (Attachment M). The results are summarized in Table I and II below.

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*These two test procedures are the primary ones recognized by EPA for evaluation of fuel economy and emissions for light duty vehicles. The requirement for test data following these procedures is stated in the policy documents that EPA sends to each potential applicant. EPA requires duplicate test sequences before and after installation of the device on a minimum of two vehicles. A test sequence consists of a cold start FTP plus a HFET or, as a simplified alternative, a hot start LA-4 plus a HFET. Other data which have been collected in accordance with other standardized procedures are acceptable as supplemental data in EPA's preliminary evaluation of a device.

Table I
Summary of Test Results Submitted by Applicant
Emissions in Grams per Mile, Fuel Economy in Miles Per Gallon

		Hot LA-4				HFET			
	Configuration	HC	CO	NOx	MPG	HC	CO	NOx	MPG
1980 Chevrolet	Baseline	.18	.39	1.38	19.0	.07	.47	1.31	24.9
3.8 liter V-6	VCD	1.21	9.85	.69	19.1	.13	2.90	.61	23.6
Veh. #3877	Average Change	+570%	+2400%	-50%	0%	+91%	+520%	-53%	-5%
1980 Chevrolet	Baseline	.20	1.20	1.64	20.1	.05	.23	1.52	26.3
3.8 liter V-6	VCD	1.15	6.76	1.43	19.7	.15	.77	1.49	25.8
Veh. #6362	Average Change	+440%	+470%	-12%	-2%	+170%	+240%	-1%	-2%

Note: MPG calculated by the carbon balance method.

Table II
Summary of Fuel Economy Results for Table I

		HOT LA-4				HFET			
	Configuration	Carbon	GPHM	PEGPHM	EMPG	Carbon	GPHM	PEGPHM	EMPG
1980 Chevrolet	Baseline	19.0	5.34	-	-	24.9	4.01	-	-
3.8 liter V-6	VCD	19.1	4.49	1.02	18.2	23.6	4.16	.10	23.6
Veh. # 3877									
	Average Change	0%	-16%	-	-	-5%	+4%	-	-
1980 Chevrolet	Baseline	20.1	5.08	-	-	26.3	3.80	-	-
3.8 liter V-6	VCD	19.7	3.82	1.47	18.9	25.8	3.77	.13	25.6
Vehicle # 6352									
	Average Change	-2%	-25%	-	-	-5%	-1%	-	-

Fuel Carbon - Fuel economy as measured by carbon balance method.

GPHM - Gallons (gasoline) per hundred miles. This fuel consumption was measured with a volumetric instrument (Fluidyne). The results correlated well with the fuel economy results measured by the carbon balance method.

PEGHM - Propane Equivalent Gallons per Hundred Miles. This is the number of gallons of propane used and expressed as the equivalent number of gallons of gasoline on a BTU basis. Gasoline is 6.167 lbs/gallon and 120,750 BTU/gallon. Propane is 4.233 lbs/gallon and 20780 BTU/lb.

EMPG - Equivalent MPG for device (volumetric fuel plus propane). It equals (1/(GPHM + PEGPHM) and should equal carbon balance value.

The overall conclusion after reviewing these data is that there is no economic or energy benefit for the device and that, except for nitrogen oxide, emissions increased. The emission effects noted - substantially higher hydrocarbon (HC) and carbon monoxide (CO) emissions with lower NOx emissions are characteristics of the effect of enriching the mixture of an engine that is calibrated to operate lean. This data showed that, from an energy standpoint, the vehicle with the device was not as energy efficient as the vehicle in stock condition.

The device was able to substitute propane for gasoline. When the data of Table II are compared on the economics of this substitution, the following table is obtained.

Table III
Summary of the Energy and Economic
Effects of Operating the VCD Device**

Vehicle #3877	HOT LA-4		HFET	
Change in fuel usage	-.85 GPHM	1.02 PEGPHM	+.15 GPHM	+.10 PEGHM
Change in fuel costs*	-$1.19/HM	+$1.25/HM	+$.21/HM	+$.10/HM
Total change in costs	+$.06/HM		+$.31/HM	
Vehicle #6362				
Change in fuel usage	-1.26 GPHM	1.47 PEGPHM	-.03 GPHM	.13 PEGHM
Change in fuel costs*	-$1.76/HM	+$1.84/HM	-$.04/HM	+$.16/HM
Total change in costs (increase)	+$.08/HM		+$.12/HM	

*Fuel costs are calculated on the basis of $1.40 a gallon for unleaded gasoline and $1.25 for the amount of propane that is energy equivalent to a gallon of gasoline (propane at $.80 gallon equals $1.05 on energy basis plus Federal and State excise taxes of $.20 a gallon).

**Abbreviations per Table II.

The following general comments also apply to this data.

(a) Propane consumption was measured with a mass balance. Unfortunately, the resolution of this balance was approximately equal to the amount of propane used in the HFET and nearly 10% of the amount used in the FTP. Although this does not appear to have adversely affected the quality of the data, it is thought to be the major source of difference between the fuel economy values calculated for the device by the carbon balance method compared to the combination of volumetric (Fluidyne) plus weight balance (propane).

(b) The modified carburetor used for the device tests on both vehicles was a unit that had been previously modified, tested, and used on other vehicles by the applicant. The test vehicles were baseline tested with their original carburetors.

(c) In an attempt to overcome a stall problem with the device, the idle propane flow was increased substantially for the second vehicle, #6362. Therefore, the device calibration was not the same for both test sequences.

(d) The stall and lean spot noted on the two test vehicles may be due to poor fuel control by the device when in transition between the idle and acceleration modes rather than a need to richen up the idle. This appears to be borne out by the fact that, after richening up the idle mixture, the second vehicle still stalled.

(e) The applicant had previously operated the test unit on other vehicles and had noted no problems with it. If the dynamometer load is higher than road load and was the cause of the problem as he infers (Attachment N), then grades or heavy loads should also be a problem. However, there was no mention of a road load problem in the applicant's previous road testing of the device.

The applicant also submitted road test data, both with and without the device, on three other vehicles. Although these were apparently well-controlled road tests, the test variables cannot be as rigorously controlled as in lab tests. Therefore, any road test results are only an uncertain indication of the effects to expect from a device.

Because of the driveability problems, negative energy benefit, and negative economic benefit shown in testing, it appears the device is actually in the prototype, development, and testing phase rather than pre-marketing. Benefits for the device, if possible, still have yet to be demonstrated and would have to be substantial to overcome the high initial cost.

7. Conclusions

EPA fully considered all of the information submitted by the applicant. The evaluation of the VCD Supplental Gaseous Fuel Delivery System was based on that information and and our engineering judgment.

The device did substitute propane for some of the gasoline. Although the substitution of propane for gasoline has the potential to affect fuel economy, emissions and operating costs, neither the data submitted by the applicant nor technical analysis showed an economic or fuel economy benefit. In fact, emission levels of HC and CO were found to increase substantially. Thus, in the absence of positive test data, EPA has no reason to support the claims made for the device or to continue the evaluation on its own.

FOR FURTHER INFORMATION CONTACT: Merrill W. Korth, Emission Control Technology Division, Office of Mobile Sources, Environmental Protection Agency, 2565 Plymouth Road, Ann Arbor, MI 48105, (313) 668-4299.

List of Attachments

Attachment A	Patent (provided with 511 Application)
Attachment B	Drawings of VCD System and description of major components of the device (provided with 511 application).
Attachment C	Letter of November 4, 1982 from EPA to Scott J. Venning of VCD Fuel Systems acknowledging receipt of 511 application request and noting it did not meet key criteria for evaluation.
Attachment D	Letter of November 29, 1982 from EPA to Scott Venning providing a review of the incomplete 511 application and requesting clarification.
Attachment E	Letter of November 29, 1982 from Scott Venning responding to EPA letter of November 4, 1982 and formally completing 511 application.
Attachment F	Letter of December 12, 1982 from Scott Venning responding to EPA letter of November 29, 1982.
Attachment G	Letter of December 15, 1982 from EPA to Scott Venning confirming information supplied and providing a test plan for the device.
Attachment H	Letter of February 22, 1983 from Scott Venning to EPA discussing proposed lab tests and containing two lab test plans.
Attachment I	Letter of February 28, 1983 from Scott Venning to EPA requesting review of a lab test plan.
Attachment J	Letter of March 16, 1983 from EPA to Scott Venning responding to letters of February 22 and 28, 1983.
Attachment K	Letter of March 18, 1983 from Scott Venning requesting review of two lab test plans.
Attachment L	Letter of April 6, 1983 from EPA to Scott Venning commenting on selection of a test lab.
Attachment M	Letter of July 11, 1983 from EPA to Scott Venning announcing intention to close out evaluation since VCD Fuel Systems had not completed the test program and submitted required data.
Attachment N	Letter of July 7, 1983 from Scott Venning providing copy of the test results at an independent lab.

Case # 211-1001-00

ATTACHMENT A

VCD SUPPLEMENTAL GASEOUS FUEL DELIVERY SYSTEM
GASEOUS FUEL DELIVERY SYSTEM

I. BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a gaseous fuel delivery system for gasoline engines. More particularly it relates to a system which supplies gaseous fuel, such as propane, methane or natural gas to the gasoline engine during idle and acceleration conditions of operation. It is an improvement of the system described in United States Patent 4,227,497.

Description of the Prior Art

The system disclosed in the aforesaid patent is intended to supply gaseous fuel to a gasoline engine during portions of the operating cycle in which gaseous fuel operation is more efficient. These selected operating conditions are idle, acceleration, and increased load.

It was determined that the use of purely mechanical means to control idle gaseous fuel supply was troublesome and inaccurate. Also, dependency upon the relative magnitudes of engine vacuum resulted in wide fluctuations in operating effectiveness. Unwanted operation of one or the other portion of the system to supply gaseous fuel when not intended further diminished overall efficiency. Importantly, it also was determined that for idle operation, modification of the carburetor of the gasoline engine equipped for gaseous fuel supply was necessary to maximize efficiency.

SUMMARY OF THE PRESENT INVENTION

The present invention is intended to provide the advantages of gaseous fuel operation in a gasoline engine without the disadvantages of the earlier design. The present invention incorporates means responsive to engine operating conditions into the idle fuel supply portion to the system. It also eliminates variable control of gaseous fuel supply during acceleration and provides positive, electrically operated cutoff of the gaseous fuel supply during periods when such supply is unneeded. This arrangement eliminates the ability to automatically respond to variable load, but significantly improves idle and acceleration performance.

The system of the present invention is applicable to new as well as existing engines. It could be supplied as original equipment or added as a conversion at some later time.

In the preferred form, the system includes supply valve means responsive to absence of flow of air through the carburetor venturi to permit supply of a preselected quantity of gaseous fuel during idle operation of the engine and responsive to loss of intake manifold vacuum to permit supply of a preselected supplemental quantity of gaseous fuel during engine acceleration. It further includes positive electrically operated valve means responsive to engine throttle position and manifold vacuum to insure delivery of idle or acceleration gaseous fuel supply only at the proper portions of the operating cycle.

The carburetor used with the system is arranged such that no gasoline fuel is delivered to the engine at idle, yet as operation is elevated above idle, a small supply of gasoline commences prior to termination of the idle gaseous fuel supply.

DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a partially sectional view of the system of the present invention.

FIGURE 2 is an electrical schematic of the electrical components of the system.

FIGURE 3 is a plan view, partially in section, of the supply valve means of the present invention.

FIGURE 4 is a side view of the supply valve means of FIGURE 3.

FIGURE 5 is a top view of the base plate of the carburetor incorporating the system of the present invention.

FIGURE 6a and 6b are fragmentary views of portions of the base plate of the carburetor of FIGURE 5.

FIGURE 7 is a fragmentary side elevational view of a portion of the carburetor of FIGURE 5.

DETAILED DESCRIPTION

The system of the present invention is applied in conjunction with the carburetor of an internal combustion engine utilizing gasoline fuel. It is interconnected, for example, with a dual barrel carburetor 10 illustrated in the drawings, which includes a removable base plate 12, central throats 14 and pivotal butterfly valve plates 15 pivotally mounted in base plate 12 and controlled by the engine throttle linkage. Of course, a carburetor having additional or fewer barrels (venturis) could be utilized. Any suitable gasoline carburetor may be used, such as the products of Rochester Carburetor Company, a Division of General Motors Corporation. Specifics of carburetor functions to supply gasoline to an engine are illustrated and described in numerous reference works, such as, for example, "Rochester Carburetor", a publication of H. P. Books, P. O. Box 5367, Tucson, Arizona 85708, printed 1973, Library of Congress Catalog Card Number 72-91 685. Reference is made to that publication for an understanding of the typical gasoline carburetor with which the present invention is intended to cooperate.

Illustrated carburetor 10 is not wholly conventional. It is modified, or in the instance of original equipment, constructed differently from a carburetor for supplying only gasoline to an internal combustion engine. Carburetor 10 includes gaseous fuel inlet tube 16 through which the gaseous fuel is supplied in accordance with the present invention. This may be located above or below butterflys 15.

In accordance with the present invention, it is necessary to eliminate all supply of gasoline fuel at idle. Usually two sources exist, the main idle circuit, which includes adjustable idle fuel jets and in most carburetors transition slots, which are formed in the throat of carburetor adjacent the closed position of the butterfly valves.

Idle needle valves are closed so that no fuel is delivered to the idle circuit of the carburetor. The idle circuit is normally a passage separate from the throat and supplies gasoline and air even though the butterfly valves are closed or nearly closed. Fuel, metered through the idle needle valves, is the major idle fuel supply. In the present system all gasoline or liquid fuel supply is eliminated at idle.

As illustrated in FIGURES 5 through 7, the carburetor of the present invention includes transition slots 22, formed in throats 14 of carburetor 10, which permit quantities of gasoline to enter the carburetor throat 14. They generally operate to supplement idle fuel supply until the main carburetor jets 17 commence fuel delivery.

As seen in FIGURES 5, 6a and 6b, the base plate 12 of carburetor 10 has been modified to significantly shorten the "transition slots" 22 which exist in the walls forming the throats 14, such that they are closed at idle and not exposed to the high intake manifold vacuum between the closed butterflys. Thus, no gasoline can be drawn into the carburetor throat. In modifying an existing carburetor 10 the slots 22 are conveniently restricted by inserting set screws 20 from the top of carburetor base plate 12. Appropriate threaded holes 24 are formed in base plate 12 to accommodate threaded set screws 20.

It is important to note that the screws are positioned such that the transition slots are blocked when the butterfly plate is in the closed or idle position. That position of plate 15 at idle is as shown at 13 in FIGURE 6a. At idle no gasoline can be drawn into the carburetor through the shortened portions 23 of slots 22, because they are above the closed portion of the butterfly. As the butterflys 15 are moved from the idle position, some amount of gasoline is drawn into the throats 15 through the shortened slots 23. This is intended to avoid any possible lag in operation as transition is made from idle to operational modes. It occurs, because as the butterflys 15 are pivoted toward the open or vertical position, the shortened slots 23 are exposed to the intake manifold vacuum.

The power valves of the carburetor 10 are also eliminated. This is done by removing, or in the case of original equipment, excluding the typical power valves found in a carburetor which enrichens the fuel mixture under load. This substantially reduces the amount of liquid fuel which will enter the carburetor on acceleration.

The fuel delivery system illustrated in the embodiment in FIGURES 1 through 8, includes a pressure vessel 26 for storage of a gaseous fuel supply, a shut-off valve 28, adjustable pressure regulator 30 with gauge 32, supply valve means 34, and connecting delivery conduits 36. The fuel utilized may be propane, methane, natural gas or similar suitable gaseous fuel. The vessel 26 may be placed in any suitable location, for example, in automotive applications it may be placed in the trunk, or between the frame rails.

Regulator 30 and gauge 32 are utilized to set an appropriate supply pressure for delivery of gaseous fuel to the supply valve means 34 at essentially constant preset pressure. As can be appreciated, the pressure level will vary with the size of the engine with which the system is associated. Typically, a system for an engine of 200 cubic inch displacement will operate satisfactorily at 1.5 to 2.0 psig. (pounds per square inch, gauge) supply pressure.

Fuel supply line 36 provides a connection between regulator 30 and supply valve means 34. Interposed in line 36 is a normally closed solenoid valve 38 connected to the electrical power supply of the engine, which in this embodiment includes battery 41. Solenoid 38 is operated by oil pressure switch 39 which closes the electrical circuit and permits solenoid 38 to open only when the engine is cranking and has developed oil pressure.

As best seen in FIGURE 3, supply valve means 34 includes a housing or body 35 forming two separate valves, idle fuel valve 42 and acceleration fuel valve 44. Supply line 36 delivers gaseous fuel through two separate inlet passages 46 and 48. These passages respectively connect to two separate discharge passages 50 and 52 across orifice defining valve seats 54 and 56.

Each of the valves 42 and 44 includes rod 58 slidably supported in bores formed in body 35. Tapered lower portions of the rods form valve plugs 64 and 65 which coact with valve seats 54, 56 to open and close communication between passages 46 and 50 and passages 48 and 52. The plugs are tapered to provide adjustability of effective orifice size of the annular opening between plug and seat when the valves are in the open position. The maximum diameter of the tapered portions exceeds the orifice size of the seats 54, 56 so that when the valves are in the closed position the orifices are completely closed.

Upper ends of rods 58 are threaded into adjustment nuts 66 which are adjustable to vary the length of the rod, nut combination, and consequently the effective orifice size of the annulus between seats 54, 56 and plugs 64, 65. It has been determined that the effective orifice size (equivalent circular orifice) for the valve 42 is in the range of .040 to .070 inches diameter and the effective orifice size for the valve 44 is in the range of .060 to .080 inches diameter. Springs 67 operate against washers 69 and urge valve rods 58 toward the open position.

Each of the rods 58 is connected to a vacuum pulloff 74, 76, through connectors 58. These vacuum motors operate, as will be explained, to seat the tapered plugs 64, 65 against seats 54, 56 under appropriate operating conditions. These devices are well known and commercially available from F&B Mfg. Co., Catalogue No. 30-3. F&B Mfg. Co. is located at 4248 West Chicago Avenue, Chicago, Illinois.

Vacuum pulloff 74 is connected via conduit 79 to the port 81 in venturi or throat of carburetor 10. Port 81 is located as would be a vacuum advance port in the throat of a carburetor. It is positioned upstream of the butterflys 15 such that when the throttle is closed and butterflys 15 are positioned as shown in FIGURES 1 and 6, the butterflys are between the port 81 and the intake manifold. When the butterflys are moved to an open position, port 81 is exposed to intake manifold vacuum and the flow of air through the throat 14.

Conduit 79 senses ported vacuum, that is, vacuum created as a result of flow of air through the venturi flowing over port 81 and operates to pull rod 58 of idle fuel valve 42 closed when there is sufficient air flow through the carburetor throat. This occurs when the engine is operating other than at idle conditions. At idle, the ported vacuum orifice 81 is blocked or disposed above the butterfly and it does not experience the intake manifold vacuum below the butterflys 15. Hence, there is no flow across it and no ported vacuum. Spring 67 urges valve 42 open. Vacuum pulloff 74 is sized such that upon experiencing a ported vacuum in excess of about 4-6 inches of mercury, it will operate against spring 67 and close idle valve 42.

It should be understood that vacuum is a negative valve. That is, a vacuum near zero, measured in inches of mercury, is a smaller or lesser vacuum than a vacuum of 4 or 10 inches of mercury.

Vacuum pulloff 76 is connected via conduit 80 to the intake manifold 82 of the engine incorporating the supplemental fuel delivery system. It senses, and responds to, manifold vacuum to pull the valve rod 58 of acceleration fuel valve 44 closed when manifold vacuum exits, such as during idle and cruise operation. Vacuum pulloff 76 is sized such that upon experiencing an intake manifold vacuum in excess of about 4-6 inches of mercury, it operates against spring 67 to close acceleration fuel supply valve 44.

Discharge port or passage 50 of idle fuel valve 42 communicates through conduit 83 to normally closed idle solenoid valve 84. Discharge port or passage 52 of acceleration fuel valve 44 communicates through conduit 86 to normally closed acceleration solenoid valve 88. These valves then communicate through conduit 90 to gaseous fuel inlet tube 16 in carburetor 10. The solenoid valves may be Skinner

#BZ DA 1052 valve or like valves from other sources. Skinner valves are made by Skinner Electric Valve Co., New Britain, Connecticut.

Microswitch 92, as best seen in FIGURE 4, is mounted upon bracket 93 connected to body 35 of the supply valve means 34. It is a two position electrical switch with contacts A and B which may be alternately energized. A suitable switch is a UNIMAX 3TMT 15-4 available from G-C Electronics, Rockford, Illinois. It senses the position of washer 69 of acceleration valve 44 to operate the switch between contacts A and B and alternately supply power to solenoids 88 and 84. As shown in FIGURE 4, bracket 93 is attached to the body 35 with bolts 97 received in slotted holes 99. This permits vertical adjustment of the switch for purposes as will be explained. Also, in the illustrated embodiment solenoids 84 and 88 are normally closed valves; that is, they are closed when de-energized. As can be appreciated, appropriate circuit modification could readily be accomplished and normally open valves used.

At idle, vacuum pulloff 76 experiences high vacuum in the range of 15-17 inches of Mercury. This holds valve 44 closed and seats plug 65 against seat 56. Feeler 94 of switch 92 senses the closed position of valve 44 and as illustrated by the schematic of FIGURE 2, connects with contact B to make power available to idle solenoid 84 which opens conduit 83 to conduit 90. At the same time, solenoid 88 is de-energized. This closes conduit 86 from conduit 90 to preclude any flow of gaseous fuel through acceleration valve 44 during idle, even if plug 65 is not tightly sealed against seat 56.

When intake manifold vacuum drops below 4-6 inches of mercury, such as during conditions of acceleration, spring 67 of valve 44 moves plug 65 away from seat 56. Feeler 94 senses the lower position of rod 58 of that valve and in accordance with the circuit of FIGURE 2, makes contact at A. Power is no longer available to solenoid 84 which opens and blocks possible flow of gaseous fuel through conduit 83 to conduit 90. Contact A energizes solenoid 88 which permits passage of gaseous fuel through conduit 86 to conduit 90.

When operating at a stable or steady state condition above idle, both pulloffs 84 and 76 experience sufficient vacuum to close respective valves 42 and 44 so that no gaseous fuel is supplied to the carbuetor 10. Also, the closed position of valve 44 is sensed by switch 92 to close solenoid 88, though this action does again make power available to solenoid 84.

To insure operation of the idle fuel supply valve 42 only at idle conditions, a second microswitch 95 is positioned upon carburetor 10 to sense the position of the throttle linkage. A UNIMAX #2HB113-1 is a suitable switch for this application. As best seen in FIGURE 7, normally open microswitch 95 is positioned on a bracket 96 with actuator arm 98 disposed to contact throttle linkage 100. Movement of linkage 100 away from idle as shown by arrow 102 causes linkage 100 to move away from actuator 98 and open microswitch 95. Switch 95 is connected in series with switch 92 and

and solenoid 84 as shown in FIGURE 2.

Starting is initiated by cranking with any suitable cranking motor. This develops sufficient engine oil pressure to close switch 39 to connect the electric circuit to the battery 41. The normally closed solenoid valve 38 is energized and gaseous fuel is made available to the supply valve means 34.

Starting normally requires more air flow into the engine than is available with a closed throttle, so throttle linkage 100 is operated to at least partially open butterfly 15. This permits air to enter the intake manifold 82 through venturi 14, which draws gasoline through main jet 17. Throttle movement also supplies gasoline for starting through conventional accelerator pumps (not shown) in the carburetor.

At the commencement of engine start-up, both vacuum pulloffs 74 and 76 experience zero vacuum and, hence, valves 42 and 44 are open across the orifice seats 54 and 56. The open position of valve 44 positions switch 92 such that contact A is converted to the power source and power is supplied only to solenoid 88. Some gaseous fuel, therefore, is at least initially supplied on startup through the acceleration valve 44.

After the engine starts, sufficient intake manifold vacuum develops, i.e., 4-6 inches of mercury, and pulloff 76 closes valve 44. This causes switch 92 to close contact B and open contact A to supply power to solenoid 84 and de-energize solenoid 88. Gaseous fuel flow through valve 44 is terminated.
Additionally, there is no flow through valve 42, even

though electrical energy is available to solenoid 84 because switch 95 is open during starting as a result of the open position of throttle butterfly 15. Once the engine starts, flow of air through venturi 14 creates sufficient ported vacuum, i.e., 4-6 inches of mercury, at port 81 of conduit 79 to close valve 42. Also, throttle linkage 100 is in other than the idle position and switch 94 remains open.

Placement of the throttle in the idle position, as illustrated in the drawings, severely restricts air flow into the engine. This air flow passes through the slight annulus between throats 14 and butterflys 15, or through holes drilled in the butterflys for that purpose. Throttle plates 15 are nearly against screws 20 in the shortened transition slots 22. The open portions 23 are above the butterflys. No fuel enters through the shortened slots.

Restricted flow causes loss of ported vacuum, i.e., to less than 4 inches of mercury. Intake manifold vacuum increases substantially to the range of 17-18 inches of mercury. Pulloff 74 no longer operates against spring 67 and, therefore, the valve 42 opens permitting flow across orifice seat 54 into conduit 83. At the same time, pulloff 76 operates against spring 67 to close valve 44. Switch 92 senses the closed position of the valve and connects electrical power to contact B, energizing and opening solenoid 84 and closing solenoid 88.

Linkage 100 is in the idle position and, therefore, switch 95 is also closed, which permits the closure of contact B of switch 92 to energize and open solenoid 84.

Gaseous fuel is permitted to flow into the carburetor through conduit 90 and inlet tube 16.

Modified transition slots permit elevation of the power level of the engine from idle without lag or sudden drop in engine output. As butterfly valve 15 is opened, the shortened portions 23 of the slots are exposed to intake manifold vacuum and the air flowing through venturi 14 draws gasoline from the reduced size transition slot. Also, as the butterflys 15 open above the port 81, it is exposed to intake manifold vacuum. Also, air flow past butterflys 15 increases. These factors increase ported vacuum and commence closure of gaseous idle fuel valve 42. As throttle linkage is moved from idle, switch 95 opens and de-energizes solenoid 84, further insuring termination of gaseous fuel supply through conduit 83. Transition slots 23, however, permit gasoline flow as soon as butterflys 15 are moved above the set screws 20. This opens slots 23 to intake manifold vacuum and allows liquid fuel to be delivered simultaneously with, or immediately prior to termination of idle gaseous fuel supply.

Under normal load, butterflys 15 are open to a position dependent on load requirements. Air flow through venturi 14 creates sufficient ported vacuum, i.e., over 4-6 psig. inches of mercury, to cause pulloff 74 to hold valve 42 closed. There is also sufficient intake manifold vacuum, i.e., in excess of 4-6 inches of mercury, to cause pulloff 76 to hold valve 44 closed. Electrically, switch 92 closes contact B, thus de-energizing solenoid 88 and making power available to solenoid 84. Throttle linkage 100, however, is out of the idle position. Hence, switch 95 is open and solenoid 84 remains de-energized. Under These conditions, fuel is supplied solely in liquid form through carburetor 10.

On acceleration, throttle 100 is operated to further open butterfly 15. This results in a loss of intake manifold vacuum. As that parameter reduces to 4-6 inches of mercury or less, vacuum pulloff 74 no longer is capable of holding valve 44 closed against the action of spring 67. As valve 44 opens, switch 92 operates to contact A and energize solenoid 88. Solenoid 84 is disconnected from the source of power and is therefore closed.

Opening of valve 44 permits gaseous fuel to pass between orifice valve seat 56 and plug 65 into passage or conduit 86. Since solenoid 88 is open, gaseous fuel is permitted to flow into conduit 90 and delivery tube 16 to supplement gasoline drawn into carburetor 10 through jet 17. Use of gaseous fuel to supplement gasoline under acceleration is advantageous because gaseous fuel is of a higher octane and enrichens the total fuel mixture using less fuel than if operated on liquid fuel alone.

Once steady state load conditions are reached, throttle butterflys 15 are moved toward a more closed position and intake manifold vacuum again exceeds 4-6 inches of mercury. This closes valve 44 to shut-off acceleration gaseous fuel supply. Also, this movement operates switch 92 to contact B, de-energizing solenoid 88. Since throttle linkage 100 is not in the idle position, switch 95 causes solenoid 84 to remain de-energized and no gaseous fuel is supplied to the engine until a condition of idle or acceleration is re-established.

It has been determined that under certain conditions of light acceleration intake manifold vacuum does not fall below the minimum at which spring 67 of valve 44 can fully override pulloff 76. At the same time, ported vacuum may also drop with the possibility that valve 42 may move slightly open.

Microswitch 92 is mounted on body 35 by bracket 93 such that it may be adjusted vertically. In this way it may be adjusted to respond to different positions of washer 69 dependent upon operating characteristics desired. Positioning of switch 92 vertically with respect to valve 44 dictates when switch 92 will close contact A, and, hence, energize solenoid 88 and de-energize solenoid 84. This switch may be positioned to respond to slight movement of rod 58, or may be moved vertically lower to respond only when the valve rod has nearly reached the end of its opening travel. If positioned in its vertically upward maximum location, it will respond to movement of valve stem 58 of valve 44 as soon as intake manifold vacuum begins to reduce below 4-6 inches of mercury, which represents the commencement of opening of plug 65 from seat 56. If positioned at the vertically lowermost position, it will not sense movement of valve rod 58 by spring 67 until the annulus between plug 65 and seat 56 is fully open. This would, for example, require reduction of intake manifold vacuum to 2-3 inches of mercury. In this way, opening of solenoid 88 can be controlled to occur at a predetermined desired condition of acceleration.

Various features of the present invention have, hence, been disclosed in connection with the illustrated embodiments of the present invention. However, numerous modifications may be made without departing from the spirit and scope of the invention as defined by the appended claims.

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CLAIMS

WE CLAIM:

1. A gaseous fuel delivery system for an internal combustion engine normally operable on liquid fuel, the combination comprising:

a.) idle delivery means responsive to engine operating conditions to supply gaseous fuel to said engine when said engine is operating at idle;

b.) acceleration delivery means responsive to engine operating conditions to supply gaseous fuel to said engine when said engine is accelerating;

c.) conduit means communicating said idle and acceleration delivery means to a source of gaseous fuel and to said engine.

2. A gaseous fuel delivery system as claimed in Claim 1 wherein said system includes:

a.) means responsive to ported vacuum created by flow of air into said engine to open and close said idle delivery means;

b.) means responsive to the vacuum in the intake manifold of said engine to open and close said acceleration delivery means.

3. A gaseous fuel delivery system for an internal combustion engine as claimed in Claim 1 wherein said system includes:

means closing communication from said idle delivery means to said conduit to the engine when said acceleration delivery means is open, and opening communication from said acceleration delivery means to said conduit to the engine said means further opening communication from said idle delivery means to said conduit to the engine when said acceleration delivery means is open and closing communication from said acceleration delivery means to said conduit to the engine.

4. A gaseous fuel delivery system as claimed in Claim 1 wherein said idle delivery means includes an idle fuel delivery valve and said acceleration delivery means includes an acceleration fuel delivery valve.

5. A gaseous fuel delivery system as claimed in Claim 4 wherein said system includes:

a vacuum pulloff connected to said idle fuel delivery valve responsive to ported vacuum created by flow of air into said engine to open and close said idle delivery means and a vacuum pulloff connected to said acceleration fuel delivery valve responsive to intake manifold vacuum of said engine to open and close said acceleration delivery valve.

6. A gaseous fuel delivery system as claimed in Claim 5 wherein said system includes:

a.) an idle solenoid valve intermediate said idle delivery valve and said engine;

b.) an acceleration solenoid valve intermediate said acceleration delivery valve and said engine; and

c.) means responsive to the opening and closing of said acceleration delivery valve to open said acceleration solenoid valve and close said idle solenoid valve when said acceleration delivery valve is open and to close said acceleration solenoid and open said idle solenoid when said acceleration delivery valve is closed.

7. A gaseous fuel delivery system as claimed in Claim 6 wherein said system further includes means responsive to the position of the throttle of said engine to permit opening of said idle solenoid valve only when said engine throttle is at the idle position.

8. A gaseous fuel delivery system as claimed in Claim 7 wherein said means responsive to the opening and closing of said acceleration delivery valve and said means responsive to the idle position of said throttle of the engine are electrical switches connected to said solenoid valves and adapted to connect to a source of electrical power.

9. A gaseous fuel delivery system for an internal combustion engine as claimed in Claim 5 wherein said vacuum pulloff connected to said idle fuel delivery valve opens said valve when the ported vacuum is about 4 to 6 inches of mercury or less.

10. A gaseous fuel delivery system for an

internal combustion engine as claimed in Claim 5 wherein said vacuum pulloff connected to said acceleration fuel delivery valve opens said valve when said engine intake manifold vacuum is about 4 to 6 inches of mercury or less.

11. A gaseous fuel delivery system as claimed in Claim 10 wherein said vacuum pulloff connected idle fuel delivery valve opens said valve when the ported vacuum is about 4 to 6 inches of mercury or less, and said vacuum pulloff connected to said acceleration fuel delivery valve opens said valve when said engine intake manifold vacuum is about 4 to 6 inches of mercury or less.

12. A gaseous fuel delivery system for an internal combustion engine, operable on liquid fuel, comprising:

a.) a supply of gaseous fuel under pressure;

b.) a gaseous fuel delivery valve means having:

- (1) an idle fuel delivery valve;
- (2) an acceleration fuel delivery valve;

c.) means responsive to engine operation to control opening and closing of said fuel delivery valve means including:

- (1) means responsive to ported vacuum to open and close idle fuel delivery valve;
- (2) means responsive to intake manifold vacuum to open and close acceleration

fuel delivery valve;

d.) Conduit means communicating said gaseous fuel from said supply to said delivery valve means and from each said idle fuel delivery valve and acceleration fuel delivery valve to said engine;

e.) electrically operable solenoid valve means arranged for alternate opening and closing comprising:

(1) idle solenoid valve means adapted to open and close said conduit means from said idle fuel delivery valve to said engine;

(2) acceleration solenoid valve means adapted to open and close said conduit means from said idle fuel delivery valve;

said means responsive to engine operation further including switch means to alternately open one said solenoid valve means and close the other thereof in response to opening and closing of said acceleration fuel delivery valve, said switch means opening said acceleration solenoid valve when said acceleration fuel delivery valve is open, closing said idle solenoid valve and, opening said idle solenoid valve when said acceleration fuel delivery valve is closed, said closing acceleration solenoid valve.

13. A gaseous fuel delivery system for an internal combustion engine as claimed in Claim 12 including solenoid valve means, interposed in said conduit from said supply to said delivery valve means and switch means responsive to oil

pressure in said engine to operate said solenoid valve means to permit gaseous fuel flow only when oil pressure exists in said engine.

14. A gaseous fuel delivery system for an internal combustion engine as claimed in Claim 12 further including idle switch means responsive to the position of the throttle of said engine to permit opening of said idle fuel delivery valve only when said throttle is in the idle position, closing said valve when said throttle is other than at the idle position.

15. Gaseous fuel delivery system for an internal combustion engine as claimed in Claim 14 wherein said:

idle fuel delivery valve and said acceleration fuel delivery valve each include an orifice defining valve seat,

a slidable rod having a plug at one end thereof surrounded by said valve seat to define a flow orifice therebetween, each said rod being movable engaging said plug with said orifice seat to close said valve.

16. A gaseous fuel delivery system for an internal combustion engine as claimed in Claim 15 wherein said idle fuel delivery valves include means urging said plug to an open position, and a vacuum pulloff connected to sense ported vacuum to close said valve when said ported vacuum exceeds a predetermined minimum, allowing said valve to open when said ported vacuum falls below said predetermined minimum.

17. A gaseous fuel delivery system for an internal combustion engine as claimed in Claim 15 wherein said

acceleration fuel delivery valve includes means urging said plug to an open position, a vacuum pulloff connected to sense intake manifold vacuum to close said valve when said intake manifold vacuum exceeds a predetermined minimum, allowing said valve to open when said ported vacuum falls below said predetermined minimum.

18. A gaseous fuel delivery system for an internal carburetor engine as claimed in Claim 16 wherein gaseous fuel is supplied to said fuel delivery valve means at from 1 1/2 to 2 pounds per square inch and said orifice deferred by said idle fuel delivery valve is equivalent in size to a circular opening housing a diameter of .040 to .070 inches.

19. A gaseous fuel delivery system for an internal combustion engine as claimed in Claim 17 wherein gaseous fuel is supplied to said gaseous fuel delivery valve means at from 1 1/2 to 2 pounds per square inch and said flow orifice defined by said acceleration fuel delivery valve is equivalent in size to a circular opening having a diameter of .060 to .080 inches.

20. A gaseous fuel delivery system as claimed in Claim 16 wherein said pulloff closes said idle fuel delivery valve when ported vacuum exceeds 4-5 inches of mercury.

21. A gaseous fuel delivery system as claimed in Claim 17 wherein said pulloff closes said acceleration fuel delivery valve when said intake manifold vacuum exceeds 4-6 inches of mercury.

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ABSTRACT

A gaseous fuel delivery system for a gasoline engine having a gaseous fuel delivery valve means comprising an idle fuel delivery valve and an acceleration fuel delivery valve. Means responsive to air flow through the carburetor throat controls operation of the idle fuel delivery valve. Means responsive to intake manifold vacuum controls operation of the acceleration fuel delivery valve. Electrically operable alternately open idle and acceleration solenoid valves are interposed in separate delivery conduits from the idle and acceleration fuel delivery valves. Means responsive to the opening of the acceleration fuel delivery valve opens the acceleration solenoid valve and closes the idle solenoid valve, reversing the respective valve positions on closing of the acceleration fuel delivery valve. An idle switch responsive to idle position of the throttle prevents opening of the idle solenoid valve except when the throttle is in the idle position.

The engine carburetor is arranged such that no gasoline is delivered for idle operation. Idle needle valves are closed, or eliminated. Transition slots are sized to be operational only as the throttle moves from the idle position and supply no fuel when the throttle is at idle.

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with full power of substitution and revocation, to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

DECLARATION AND POWER OF ATTORNEY

As a below named inventor; I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name; that

I verily believe I am the original, first and sole inventor (if only one name is listed below) or a joint inventor (if plural inventors are named below) of the invention entitled:

GASEOUS FUEL DELIVERY SYSTEM

described and claimed in the attached specification; that

I do not know and do not believe that the same was ever known or used in the United States of America before my or our invention thereof, or patented or described in any printed publication in any country before my or our invention thereof or more than one year prior to this application, that the same was not in public use or on sale in the United States of America more than one year prior to this application, that the invention has not been patented or made the subject of an inventor's certificate issued before the date of this application in any country foreign to the United States of America on an application filed by me or my legal representatives or assigns more than twelve months prior to this application, that I acknowledge my duty to disclose information of which I am aware which is material to the examination of this application, and that no application for patent or inventor's certificate on this invention has been filed in any country foreign to the United States of America prior to this application by me or my legal representatives or assigns, except as follows:

And I hereby appoint Robert V. Jambor, Registration No. 23,080, Dorsey L. Baker, Registration No. 24,888, Gomer W. Walters, Registration No. 22,370 and Jay G. Taylor, Registration No. 25,799, whose address is Haight, Hofeldt, Davis & Jambor, 3614 Mid Continental Plaza, 55 East Monroe Street, Chicago, Illinois 60603, telephone number (312) 263-2353, my attorneys or agents

Fig 1

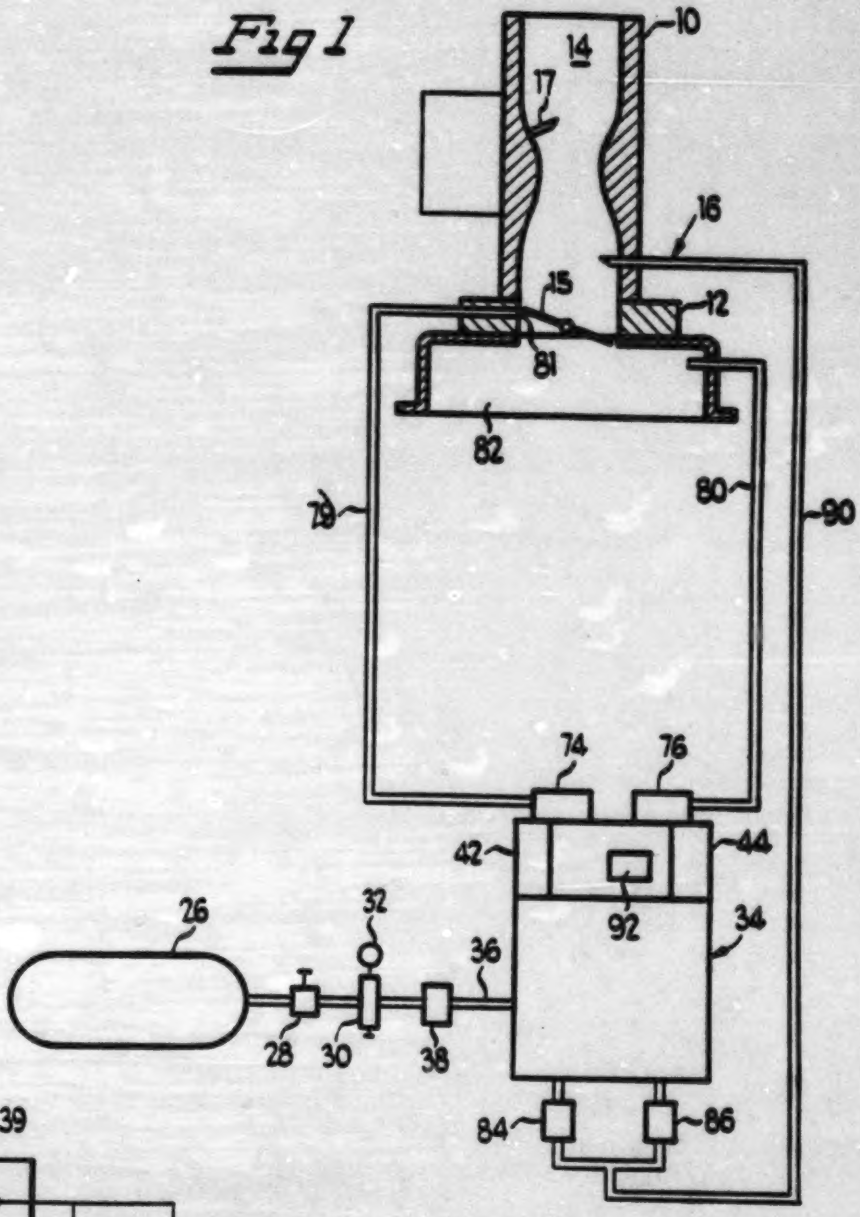


Fig 2

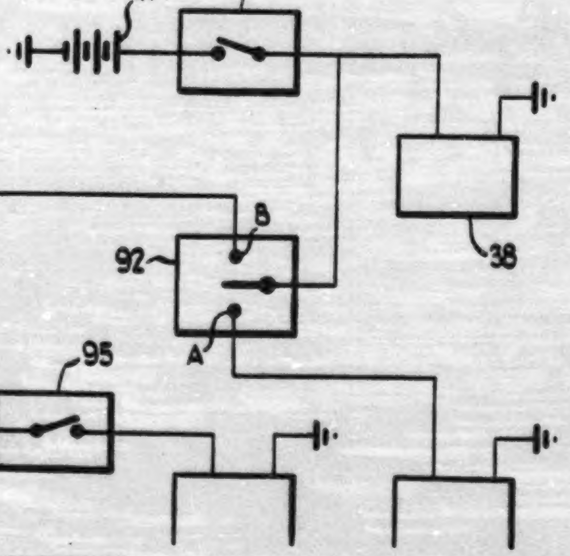

B
A

Fig 3

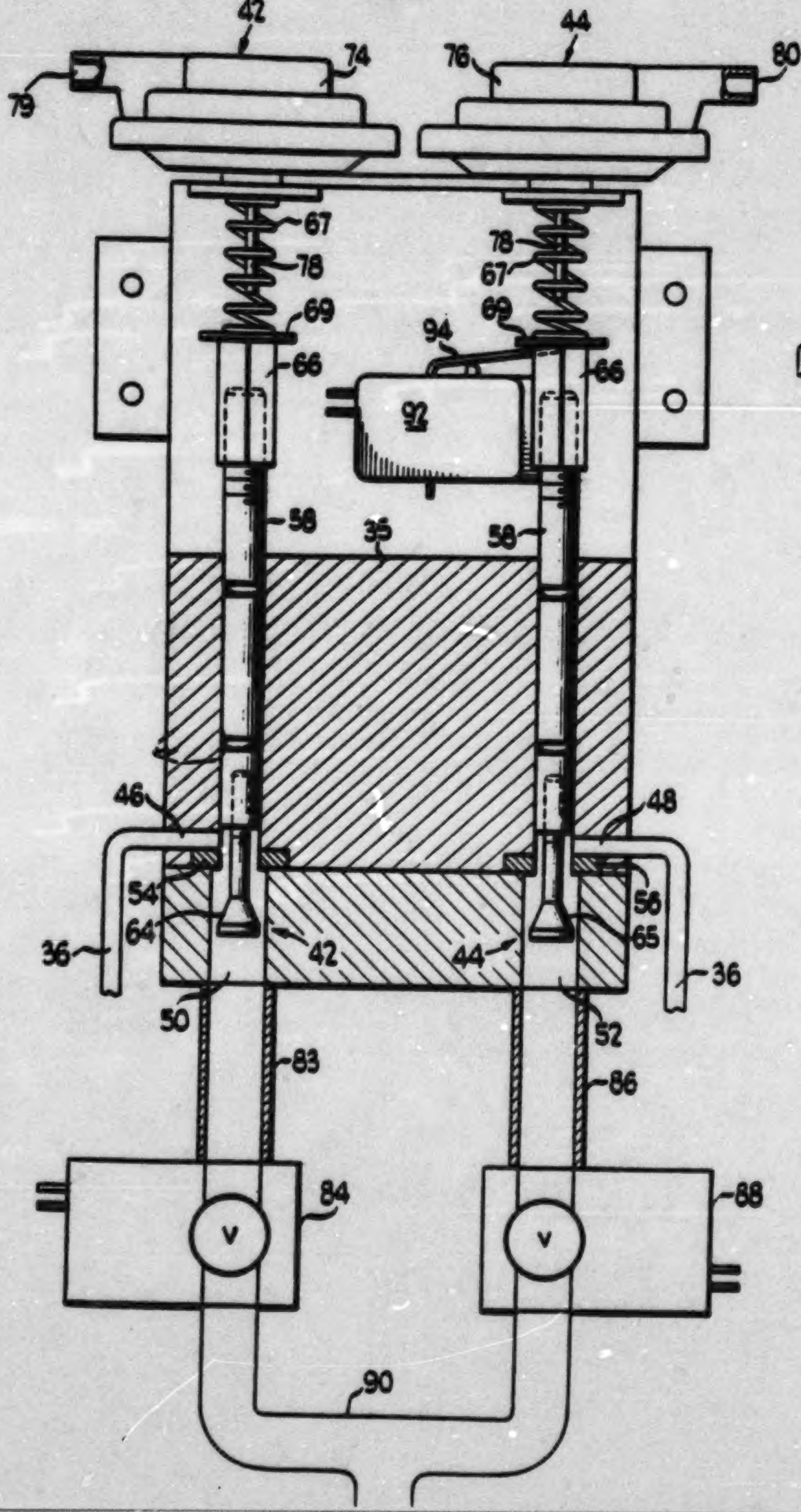
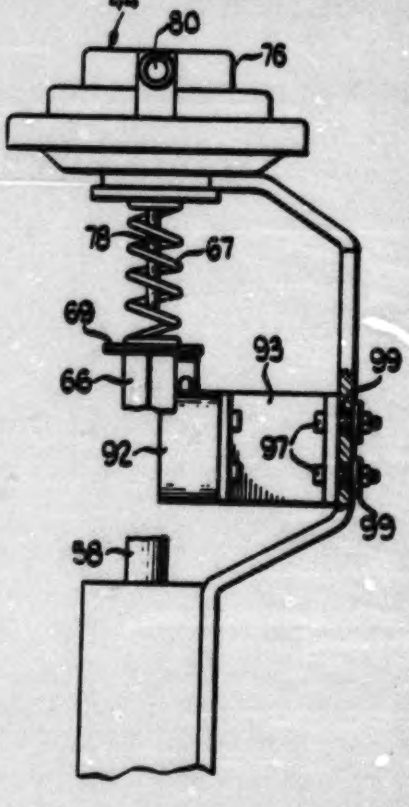

V
V

Fig 4



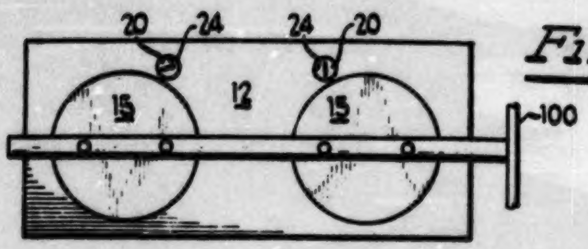

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Fig 5

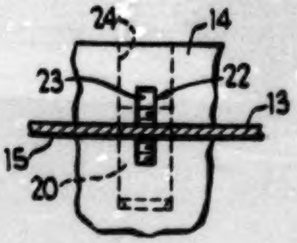
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Fig 6a

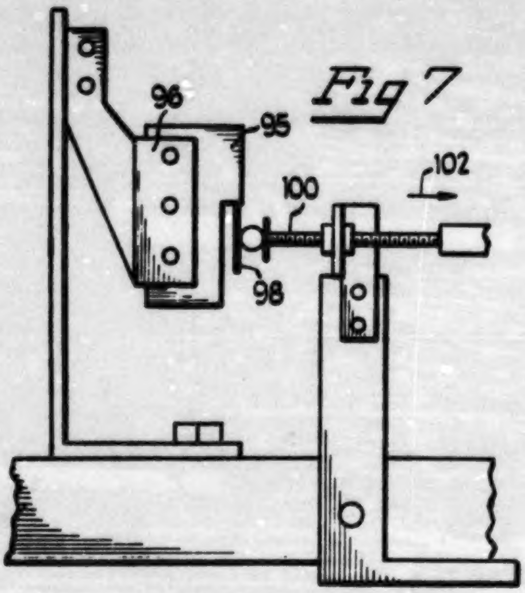
96
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Fig 7

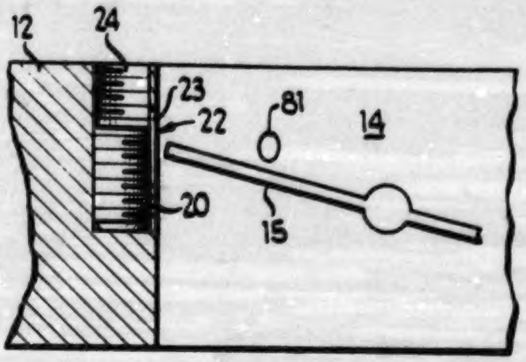
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Fig 6b

ATTACHMENT B

Major Components of the VCD Device

1. Description of Metering Unit:

"(Fig. 1) Propane enters metering unit (#20). On idle requirements, idle vacuum pulloff (connected to ported vacuum) is allowing tapered needle valve (#21) to be opened, allowing propane to travel thru idle solenoid (#2) then into carburetor. At the same time, micro switch (#27) is electronically closing accel solenoid (#16) and keeping idle solenoid (#2) open. Entering cruising stage of vehicle, ported vacuum develops, pulling idle vacuum pulloff closed, in turn, closing tapered needle valve (#21) idle side. Upon acceleration, accel vacuum pulloff, losing manifold vacuum, opens tapered needle valve (#22) accel side, allowing propane to pass thru accel solenoid (#16) then into carburetor. Meanwhile, micro switch (#27) electronically shuts off idle solenoid (#2) and opens accel solenoids (#16). If returning to idle mode, manifold vacuum will come up, closing accel side and ported vacuum will drop, opening idle side. Simultaneously, (electronically thru micro switch #27) idle solenoid will open and accel will close.

2. Idle Switch Description:

"(Fig. 6) During moderate acceleration the vacuum may fall to 8" - 4". The vacuum pulloff will start opening at 4" - 6". If the vacuum does not fall to 4" or below, accel side will not open fully and activate micro switch. In this condition, idle side and accel side are slightly open, but since the micro switch only opens and closes solenoids opposite of each other, the idle solenoid is open and propane will flow until vacuum falls below 4" and opens accel side completely, causing micro switch to open accel solenoid and closing idle side.

"If vacuum was regained instead of falling, it would close both vacuum pulloffs.

"The idle switch keeps the idle solenoid closed by throttle position, solving the problem of moderate accelerating conditions not fully opening accel side.

"The micro switch on the unit is adjustable in location. To raise switch, propane would flow sooner under accel conditions (opening solenoid sooner). To lower switch, would delay propane to more extreme conditions. The lower the switch is located, [the more] the idle switch becomes a necessity. If the micro switch is lowered, the vacuum pulloffs can open farther when low vacuum conditions occur [thereby] not allowing micro switch to be activated."

3. Carburetor Modifications:

"(Fig. 4 & 5) Idle circuit must be closed off only allowing a portion of the transition slot to be used. Propane inlet can be installed in carburetor throttle bore, thru manifold or base plate. Idle switch must be installed and able to be adjusted for near closed throttle position. Power valve must be eliminated and main jetting should be made to adjust for leaner conditions."

4. General:

"(Fig. 1) For idle mixture, tapered needle valve (#21) idle side, is adjustable by threaded shaft and locking nut (#25). Power to unit is run thru an oil pressure switch so propane cannot flow without engine running with oil pressure. If engine died and [the] key [is] left on, oil pressure would drop, cutting off propane to eliminate an unsafe condition. Micro switch (#27) is adjustable for synchronizing idle and accel solenoids."

5. Variations of System:

a. System V-1: "Mechanical system, idles on propane, cruises and accelerates on gasoline.

"Standard carburetor with propane idle circuit only. Carburetor preparation includes idle switch, transition slot modifications and propane inlet. Metering device using only idle side. This system uses standard functions of carburetor except for the economic advantage of idling only with propane.

"This system uses a switch to activate an electronic solenoid with reference to throttle location. The solenoid has removable jets to adjust the volume of propane.

"When the throttle is closed, the switch electronically opens the solenoid. As the throttle is brought off of the idle position, the switch closes the solenoid cutting off the propane and resumes on gasoline like a conventional carburetor.

"This system uses the following items:

Pressure Tank
Shut Off
Safety Switch - Activated by Oil Pressure
Fuel Line
Electronic Solenoid
Jet
Micro Switch
Modified Carburetor
    Idle Switch

Modified Transition Slots
Propane Entry Tubes"

b. Metering Unit for V-2 and V-3

"This unit will give the same results as original unit but is greatly simplified. Using adjustable vacuum switches in place of vacuum pull-offs, the vacuum requirements can be adjusted. As far as metering propane, moving needles and seats are replaced with jets and can be changed for desired orifices. Solenoids control propane flow and are activated electronically by vacuum switches."

c. System V-2

"Vacuum system, idles on propane, cruises and accelerates on gasoline.

"This system uses a vacuum switch that is adjustable for vacuum requirements. This switch is connected to ported vacuum. When the throttle is closed, there is no vacuum going to the vacuum switch, so the vacuum switch produces a closed circuit, opening the electronic solenoid letting propane into the carburetor. As the throttle is opened, ported vacuum arrives to the vacuum switch, opening the circuit, closing the electronic solenoid. The propane is cut off and the carburetor proceeds to the conventional gasoline operation.

"The idle switch (micro switch) is used on this system because, under load, the vacuum drops and will open the solenoid. The idle switch lets the system be operational only under near-closed throttle position letting the system operate only when idling.

"The system using the vacuum rather than a mechanical means is a more accurate method.

"This system uses the following items:

Pressure Tank
Shut Off
Regulator
Safety Switch - Activated by Oil Pressure
Fuel Line
Adjustable Vacuum Switch
Electronic Solenoid
Jet
Micro Switch
A body with passages on which to mount vacuum switch and solenoid.

Modified Carburetor
    Idle Switch
    Modified Transition Slots
    Propane Entry Tubes"

d. System V-3

"Vacuum system, idles on propane, cruises on gasoline, accelerates on propane and gasoline.

"This system used the same principle to idle. For acceleration the power valve in the carburetor is bypassed and a second stage is added to the system. This requires another vacuum switch and solenoid.

"The accel side of the system runs off of manifold vacuum. When the load requirements of the engine become greater and the vacuum falls to 4", the vacuum switch opens the accel solenoid which is jetted also, and delivers propane to the already present gasoline mixture to enrichen the mixture acting as a power valve. Less fuel can be used this way because the propane added to the gas mixture has higher octane than a conventional system.

"This system uses the following items:

Pressure Tank
Shut Off
Regulator
Safety Switch - Activated by Oil Pressure
Fuel Line
2 - Adjustable Vacuum Switches
2 - Electronic Solenoids
2 - Jets
Micro Switch
A body with passages on which to mount vacuum
    switches and solenoids.
Modified Carburetor
    Idle Switch
    Modified Transition Slots
    Propane Entry Tubes
    Plugged Power Valve and Power Circut"

2- Idle Solinoid
16- Accel Solinoid
20- Propane Inlet
21- Tapered Valve (idle side)
22- Tapered Valve (accel side)
23- Seat
24- Propane Supply to Carb
25- Locking Nut
26- Spring
27- Micro Switch
28- Vacuum Pulloff (idle side)
29- Vacuum Pulloff (accel side)

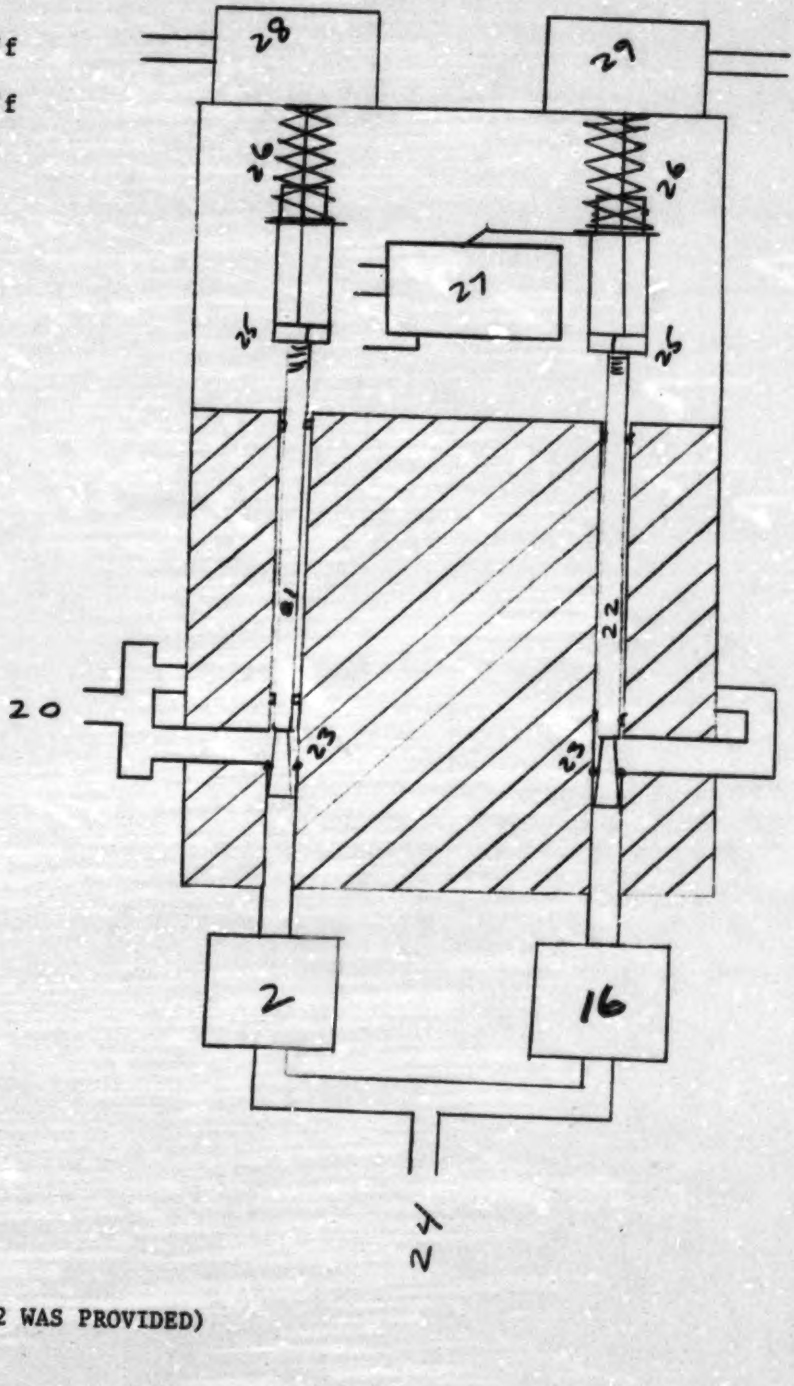

28
29
26
26
27
25
25
21
22
20
23
23
2
16
24

FIG. 1

(NO FIGURE 2 WAS PROVIDED)

FIG. 3

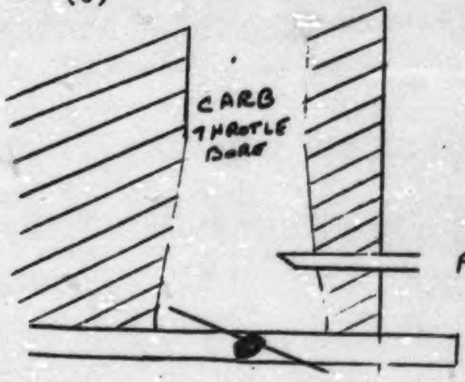

CARB
THROTLE
BORE
PROPANE INLET

FIG. 4

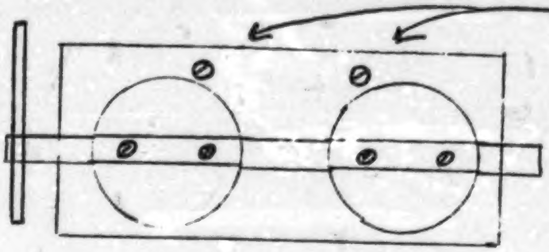

TOP VIEW
BASE PLATE

FIG 5

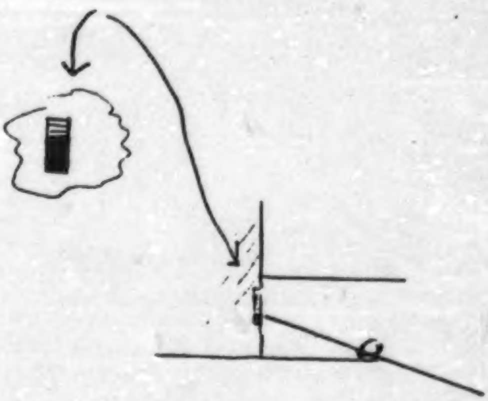

TRANSISTION SLOT

FIG. 6

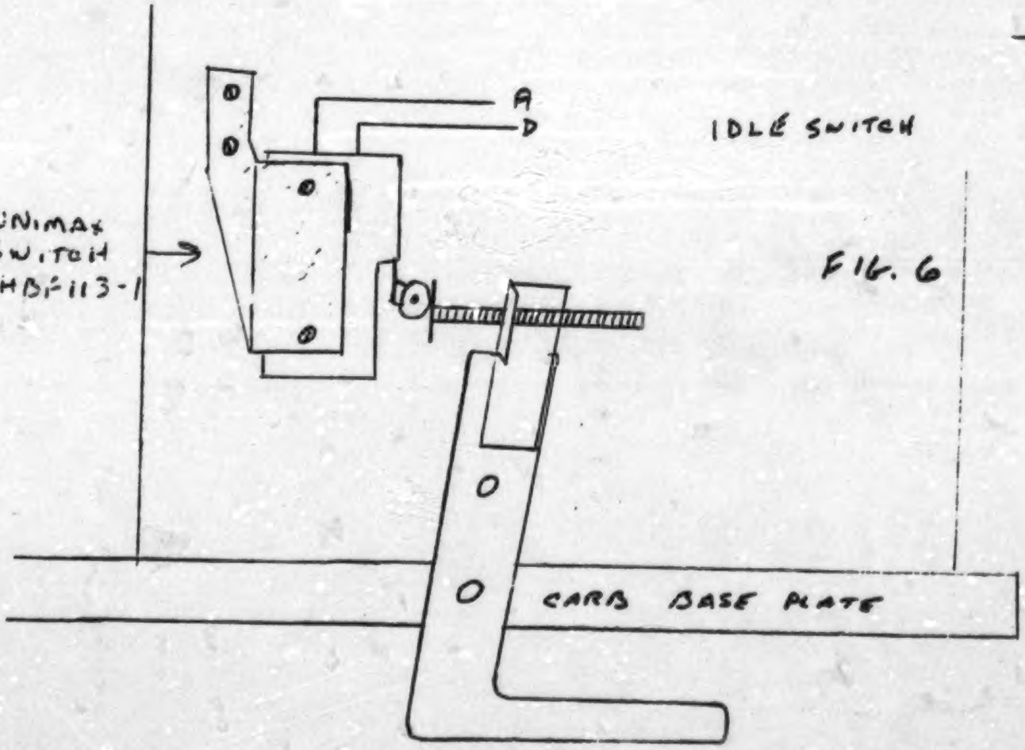
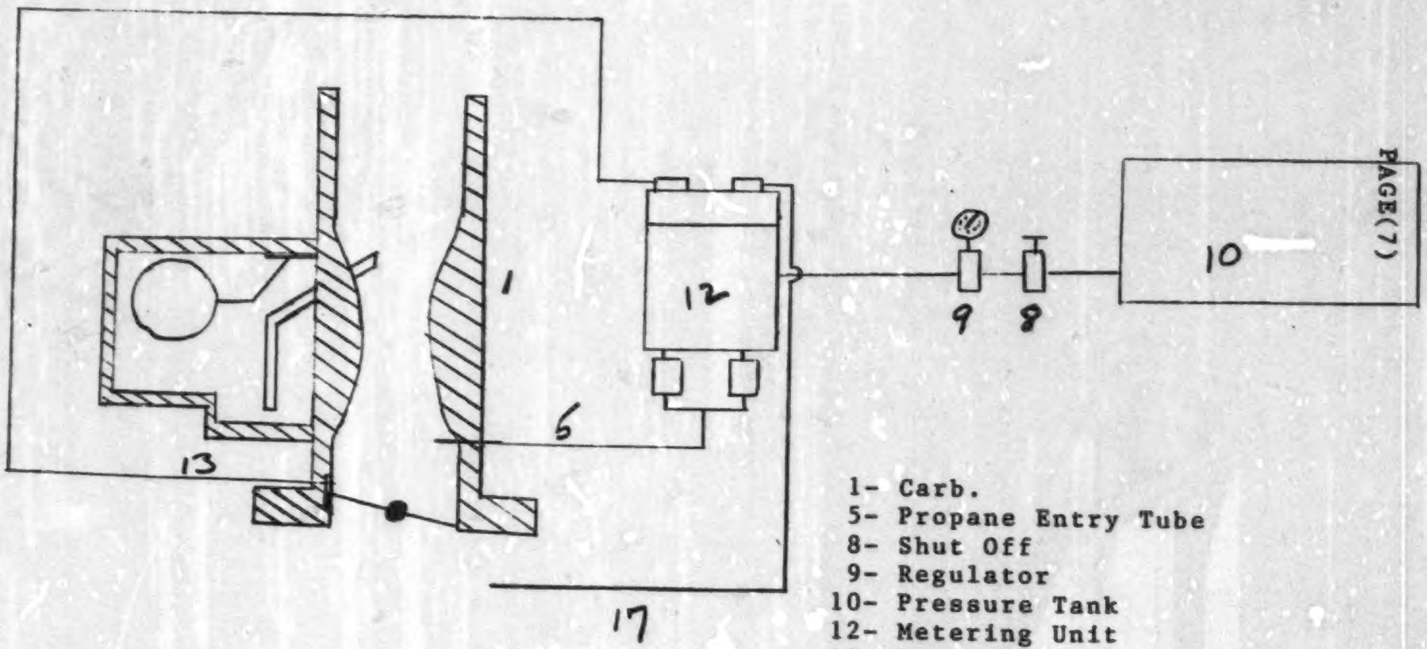

A
D
IDLE SWITCH
UNIMAX
SWITCH
2HBF113-1
CARB BASE PLATE

FIG 7



1- Carb.
5- Propane Entry Tube
8- Shut Off
9- Regulator
10- Pressure Tank
12- Metering Unit
13- Ported Vacuum
17- Manifold Vacuum

. . . VCD 1

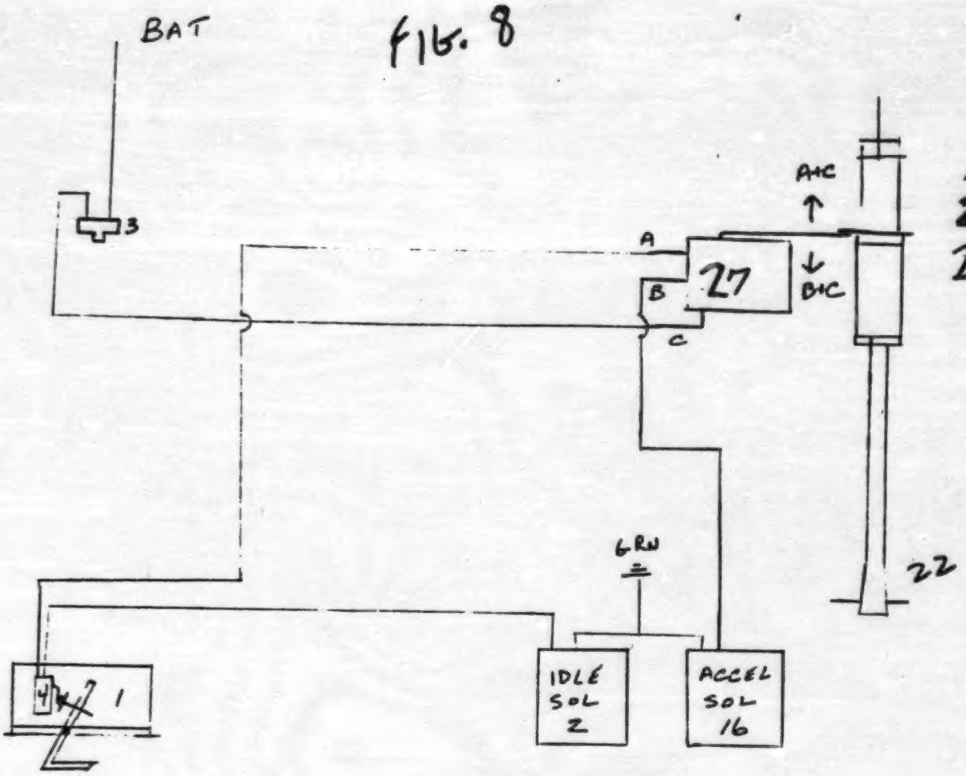
WIRING DIAGRAM IN IDLE POSITION

(Page #8)

1- CARB
2- IDLE SOLINOID
3- OIL PRESSURE S
4- IDLE SWITCH

16- ACCEL SOLINOID
27- MICROSWITCH
22- ACCEL VALVE

FIG. 8


BAT
3
A
B
C
27
A/C ↑
↓ B/C
22
GRN
IDLE SOL 2
ACCEL SOL 16
4
1

#4 SWITCH - CLOSED CIRCUT

#2 IDLE SOL - ACTIVATED AND OPEN

#27 MICROSWITCH - CONTACT A+C CLOSED

#16 ACCEL SOLINOID - NO POWER - CLOSED

#22 ACCELVALVE - UP + CLOSED

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
ANN ARBOR, MICHIGAN 48105

ATTACHMENT C

November 4, 1982

OFFICE OF
AIR, NOISE AND RADIATION

Mr. Scott J. Venning
617 South Busse Road
Mount Prospect, IL 60056

Dear Mr. Venning:

On October 13 we received your letter of September 29 in which you applied for an EPA evaluation of your "VCD Supplemental Gaseous Fuel Delivery System". Our Engineering Evaluation Group has made a preliminary review of your application and has determined that it does not meet the key criteria necessary for an evaluation. Namely, that you do not claim either a fuel economy or emission benefit for your device.

As stated in the package of documents I sent you, our authority and obligation to evaluate devices is limited to those devices for which either an emission or fuel economy benefit is claimed. Your application claims only that the device substitutes propane for gasoline and will not raise the emissions of a vehicle to levels exceeding the statutory limits. Therefore, at this time, we cannot further process your application.

The data that you submitted indicated that your device might be able to reduce fuel costs and save energy. If you feel that these results are representative of the benefits that would be achieved in a controlled test of the type described in our package, you could make specific emission or fuel economy claims based on this data. As an alternative, you could either conduct the appropriate testing or perform an engineering analysis and then base the specific claims on this testing or analysis.

Although we cannot now process your application, if you do decide to test, we will be happy to assist you in developing a test plan that would also satisfy the requirements for testing at an independent lab. Also, since several items in your application will require clarification or additional information when we resume the evaluation process, I will advise you of these items shortly so that the evaluation may proceed efficiently after the claims issue is satisfactorily resolved. If I can be of any further assistance, please contact me at (313) 668-4299.

Sincerely,

/s/

Merrill W. Korth
Device Evaluation Coordinator
Test and Evaluation Branch

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
ANN ARBOR, MICHIGAN 48105

ATTACHMENT D

November 29, 1982

OFFICE OF
AIR, NOISE AND RADIATION

Mr. Scott J. Venning
617 S. Busse Road
Mount Prospect, IL 60056

Dear Mr. Venning:

As promised in my letter of November 4, I am writing to discuss your application for an EPA evaluation of the "VCD Supplemental Gaseous Fuel Delivery System."

Our Engineering Evaluation Group has conducted a preliminary review of your application and has identified several areas besides the emission or fuel economy issue that appear to require clarification prior to further processing. Our comments below address each section individually.

1. Section 2a. - Marketing Identification. Your application identified several versions of the device but did not clearly define the evaluation status of each. I have listed these versions and the status that we assume applies to each.

   a. "VCD Supplemental Gaseous Fuel Delivery System" - It is a mechanical system that causes an engine to idle on propane, cruise on gasoline, and accelerate on a mixture of propane and gasoline. Your application applies to this version. This is the version that will be tested and to which the submitted test data applied.

   b. "V-1" - This is a mechanical system that causes the engine to idle on propane while still cruising and accelerating on gasoline. This is a simplified version of the device and is not to be evaluated. The description of this version was supplied for background purposes only.

   c. "V-2" - This is a vacuum system that causes the engine to idle on propane while still cruising and accelerating on gasoline. This is also a simplified version of the device and is not to be evaluated. The description of this version was supplied for background purposes only.

   d. "V-3" - This is a vacuum system that causes an engine to idle on propane, cruise on gasoline, and accelerate on propane and gasoline. This version is functionally similar to the VCD Supplemental Gaseous Fuel Delivery System. While the application also applies to this version, you do not plan to test it.

2. Section 3b. - Applicability. Your application states that the system is applicable to all gasoline internal combustion engines. However, after reviewing the application, it appears that the system is not applicable to fuel injected engines or ones with throttle body injection. Therefore, we assume the device is not applicable to these engines.

   Is the device applicable to vehicles using feedback carburetors?

   The application identified only one engine family for which the device actually exists (the 229 CID GM V-6 engine). If you have developed the system for other engine families, please identify these combinations.

3. Section 3c. - Theory of Operation. It appears the modifications to the carburetor have leaned it out by reducing or eliminating the contributions of the idle circuit and power enrichment circuits to off idle conditions. Is this the case? Since vehicles that use feedback carburetors will select a factory pre-programmed fuel/air ratio, will the device cause the vehicle to function as you wish when using it on a vehicle which is so equipped?

4. Section 3d. - Construction and Operation. When accelerating, the VCD accelerator circuit injects propane whenever the intake manifold vacuum drops below 4 to 6 inches (Hg). Is the same setting used for all vehicle/engine combinations, e.g., for 4, 6, and 8 cylinder engines?

   For the system described in paragraph 1a. above, do the mechanical valves modulate the propane flow or simply turn the flow from off to full on?

5. Section 3e. - Specific Claims. As I noted in my letter of November 4, this evaluation process only applies to devices which claim either an emissions or fuel economy benefit. No such benefit was claimed in the application.

6. Section 3f. - Cost and Marketing. What is the cost of the device including all parts necessary for installation? How is the device to be marketed? Has the device completed development? Is the device now produced and marketed?

7. Section 4a. - Installation. The application only summarizes this critical area.

   a. The procedures and setpoints for adjusting the propane flow and micro switches were not given. Please describe.

   b. The safety of the installation is crucial. In lieu of detailed instructions, a statement of the applicable industry standards and practices that are adhered to in installing the system is necessary.

   c. What is the typical total time required for installation and checkout of the device?

8. Section 4b. - Operation. The modifications to the carburetor greatly reduce the amount of gasoline available for starting. Since propane is only provided after the engine is cranking, some details on starting are needed.

   a. At what oil pressure does the propane safety switch allow propane to flow?

   b. How many seconds after the start of cranking does the typical vehicle reach this oil pressure and thus allow propane to flow?

   c. Does this time delay for propane flow remain constant for all ambient temperatues?

   d. Are there any cold starting problems related to this system?

   e. At what ambient temperatures has the system been successfully started?

9. Section 4c. - Safety. What industry safety standards does the system meet?

10. Section 5b. - Regulated Emissions and Fuel Economy. No description of the test methods or procedures was given. I presume these were either city or highway road tests. While such tests are useful in the preliminary evaluation of a device when sufficient details are provided, a strictly controlled test of the type described in the package we sent you previously is required to most accurately assess the worth of a product.

Assuming you are able to satisfactorily resolve the problem of fuel economy or emission benefits, it will be necessary for you to undertake testing at an independent laboratory. In order to efficiently assist you, I will need your timely reply. Please respond by December 17. If I can be of any further assistance, please call me at (313) 668-4299.

Sincerely,

Merrill W. Korth
Device Evaluation Coordinator
Test and Evaluation Branch

2-12 VCD Rec'd 12-7-82
mwk

VCD FUEL SYSTEMS
617 S. BUSSE ROAD • MT. PROSPECT, IL 60056 • (312) 593-2184

ATTACHMENT E

November 29, 1982

Merrill W. Korth
EPA
Motor Vehicle Emission Laboratory
2565 Plymouth Rd
Ann Arbor, Mi 48105

Dear Mr. Korth;

Pertaining to the APPLICATION FOR EVALUATION OF A FUEL ECONOMY RETROFIT DEVICE UNDER SECTION 511 OF THE ENERGY POLICY AND CONSERVATION ACT format dated September 29, 1982, I am sending an amended section.

DESCRIPTION OF DEVICE:

A. Purpose of the device:this system is to save fuel and money. Through testing we have established that idling with propane is more economical than gasoline and cruising with gasoline is more economical than propane. With the combination of idling on propane and cruising with gasoline, we have arrived with a considerable savings of fuel and money.

Up until now, all propane converted vehicles used only propane and had no fuel or money savings, only availability to an alternative fuel when gasoline is unavailable or in shortage. Using propane only has the disadvantage of a 20% power loss.

The VCD System also accelerates on gasoline and propane. Together, this anables you a leaner power circuit because the slight amount of propane used helps as does octane in fuel. We have included test results that we have performed. We feel that this system will be benificial to the energy problem and save the public money.

Sincerely,

Scott V

SCOTT VENNING

SV:d
Encl.

Test Results (Regulated Emissions and Fuel Economy):

Test #1 1980 Monte Carlo
V6 229 C.I.
Air Conditioning
Automatic transmission

Stock Form:
16.5 MPG
Air conditioning on

With VCD System - 100 Mile Tests

Test-A 22.8 MPG
2.29 Lbs Propane

Test-B 24.0 MPG
2.35 Lbs Propane

Test-C 23.4 MPG
2.4 Lbs Propane

$1.26 Gasoline per gal.

.25 Propane per lb.

Comparison:

Stock Form
16.5 MPG
6.06 Gal. Gasoline
$7.63 Gasoline Cost

VCD System
22.8 MPG
4.38 Gal. Gasoline
$5.47 Gasoline Cost
.57 Propane Cost
$6.04 Total Cost

$7.63
6,04
$1.59 = 20.7%

Test #2 1980 Malibu
V6 229 C.I.
Air Conditioning
Automatic transmission

Stock Form:
16.2 MPG
Air conditioning on

With VCD System - 100 Mile Tests

Test-A 23.3 MPG
3.29 Lbs Propane

Test-B 23.3 MPG
2.98 Lbs Propane

Test-C 23.6 MPG
3.8 Lbs Propane

$1.26 Gasoline per gal.

.25 Propane per lb.

Comparison:

Stock Form	VCD System
16.2 MPG	23.3 MPG
6.17 Gal. Gasoline	4.29 Gal. Gasoline
$7.77 Gasoline Cost	$5.40 Gasoline Cost
	.82 Propane Cost
	$6.22 Total Cost

$7.77
6.22
$1.55 = 20%

Test #3 1980 Malibu
V6 229 C.I.
Air Conditioning
Automatic transmission

Stock Form:
17.9 MPG
Air conditioning on

With VCD System - 100 Mile Tests

Test-A 24.8 MPG
3.2 Lbs Propane

Test-B 23.6 MPG
3.0 Lbs Propane

Test-C 25.1 MPG
3.1 Lbs Propane

$1.26 Gasoline per gal.

.25 Propane per lb.

Comparison:

Stock Form	VCD System
17.9 MPG	24.8 MPG
5.58 Gal. Gasoline	4.03 Gal. Gasoline
$7.03 Gasoline Cost	$5.07 Gasoline Cost
	.80 Propane Cost
	$5.87 Total Cost

$7.03
5.87
$1.16 = 16.5%

Test #4 (Same car as in Test #3)

1980 Malibu
V6 229 C.I.
Air Conditioning
Automatic transmission

IDLING ONLY TEST: (400 RPM In Gear - Air Conditioning On)

Test-A

Stock 31.5¢ 1 Quart Gasoline - 25 Min. 40 Sec.

Propane 22.5¢ 410 Grams - 25 Min. 40 Sec.

29% Savings With Propane

Test-B

Stock 31.5¢ 1 Quart Gasoline - 25 Min. 10 Sec.

Propane 21.8¢ 397 Grams - 25 Min. 10 Sec.

30.8% Savings With Propane

VARIATIONS OF SYSTEM:

Standard carburetor with propane idle circuit only. Carburetor preparation includes idle switch, transition slot modifications and propane inlet. Metering device using only idle side. This system uses standard functions of carburetor except for the economic advantage of idling only with propane.

METERING UNIT: V-2 and V-3

This unit will give the same results as original unit but is greatly simplified. Using adjustable vacuum switches in place of vacuum pull-offs the vacuum requirements can be adjusted. As far as metering propane, moving needles and seats are replaced with jets that can be changed for desired orifices. Solinoids control propane flow and are activated electronically by vacuum switches.

file VCD Received 12-16-82
mwk

VCD FUEL SYSTEMS
617 S. BUSSE ROAD • MT. PROSPECT, IL 60056 • (312) 593-2184

ATTACHMENT F

December 12, 1982

Merrill W. Korth
EPA
Motor Vehicle Emission Laboratory
2565 Plymouth Road
Ann Arbor, Mi 48105

Dear Mr. Korth;

Pertaining to your letter dated November 29th, I hope the following answers will resolve any questions that had developed.

1. Section 2A - I plan to test only the VCD Supplemental Gaseous Fuel Delivery System. The other systems are variations and were included as background information only.

   V-3 and a system with only the idling on propane modification utilized are to have further testing in the future

2. Section 3B - Applicability. This system will not be applicable to fuel injected engines. We feel if this system proves to be as economical as believed, engines that are fuel injected could be converted or a system using this theory could be developed.

   (Feedback carburetor) If you are referring to a feedback carburetor as a system using a computer tied into the carburetor, as in 1981 and later GM engines, we feel the VCD system could be adapted but testing would be necessary.

   The VCD System we tested was used on various 229 CID GM V-6 engines. Some testing was performed on 350 CID CHEV V-8 4 BBL carb engines. We also started developing a system for Ford 351-M engines, We would like to test with the GM V-6 229 as all of our testing and research has been directed to these engines.

3. Section 3C - Theory of Operation. The idle circuit has been converted to propane only. Power enrichment has been accomplished by the addition of propane and not additional gasoline. With the VCD Propane System in a standard carburetor, the main jetting can be leaned without experiencing any lean driving conditions. Leaning the main jetting is not necessary in this system but will further fuel economy.

   Using a feedback computer carburetor, we feel that the main jetting will have to remain the same but the most significant savings will come in the idling only on propane and accelerating on both propane and gasoline. Setting up the system this way, the fuel/air ratio can remain the same but using different fuels that prove more economical at specific times.

4. Section 3D - Construction and Operation. As far as injecting of propane under acceleration, we have had this system on Chev 350 CID V-8 4BBL engines and found the vaccuum requirements the same as in other installations. By adjusting the micro switch, connected to the accel side, you can speed up or delay propane for under load requirements. (see detailed explaination in format Pg 3 last para).

   The mechanical valves do not modulate. They move to fixed positions. In the V-3 system, they are simplified by using only removable jets.

5. Section 3E - Specific Claims. A letter was sent to you dated November 29th, 1982 referring to this matter.

6. Section 3F - Cost and Marketing. The cost of this system at this point is approximately $700.00 - 900.00. This device is to be marketed to manufactures of motor vehicals and possibly to large fleets. The VCD Supplemental Gaseous Fuel Delivery System has completed development. The V-3 and a system using only the idling on propane modification are still under development. We have only prototypes produced at this time. This is why we need to have our system evaluation by the EPA. This will put us in a position to continue to develop our later systems including V-3 system and idling on propane only modification system, adapting and testing on computer feedback carburetor engines.

7. Section 4A - Installation. This system is not intended for the public to purchase and install themselves. It is to be used by auto manufactures and large fleets. This will enable us to work specifically with the type of vehicle and with the personnel installing the systems.

3)

A. Propane flow (idle side) is accomplished by synchronizing the valve in unit, allowing propane to flow and the throttle butterfly opening in carburetor.

To adjust idle, the idle stop adjusting screw is used to open butterfly and the propane valve is adjusted to achieve proper idle speed. By adjusting both, you will have a smooth idle at any desired speed. On a conventional carburetor, the idle circuit is included in the carburetor and adjusting the idle stop screw, opening or closing the butterfly, the carburetor will automatically allow more fuel to enter to maintain the proper air fuel mixture. With the VCD System, the propane flow and the butterfly work independently so the butterfly opening is compensated by the propane flow on the valve in the device.

Propane flow (accel side) is adjusted to obtain a smooth transition to the power circuit from cruising mode by opening and closing accel valve. The micro switch on the accel side will also allow fine adjustment to when the valve starts to open by the vaccuum situation. (note format, page 3 last para.).

B. This system is safe to work with and is to be regarded to as you would working with a gasoline only system. All fittings and hoses must be checked for leaks. The pressure must be maintained at 1½ - 2 lbs. The propane tank,as in our installation, is under pressure but is being used in many vehicles safely and effectively today.

C. Having a modified (will be on exchange basis or produced with modifications for original equipment). The system can be installed by trained personnel in approx. 1½ hours with allowing for adjusting and check out time.

8. Section 4B - Operation. Starting is no problem and is like starting with a conventional carburetor. The accelerator pump is still used and will allow plenty of fuel as the accelerator is pumped for starting.

A. Propane will flow at 5lbs. oil pressure. Switches are available with adjustable settings if any problem would arrive in the future or with a perticular installation.

B. The accelerater pump will allow fuel for starting and when you are out of the idle postion the engine will run normally on gasoline.As the throddle is released after a few seconds, oil pressure will be up and then will allow propane to flow for idling.

C. The propane flow seems to be constant through all temperatures. In severe cold the oil pressure comes up slower but the engine will run above idle at any time (with or without oil pressure) allowing the extra few seconds to get oil pressure needed in severe cold.

D. We have not experienced any cold starting problems.

E. This system has been tested in Chicago over a 2 year period. Temperatures experienced and had success in starting and complete operation.
90 - 95 degrees, 40 - 80, 10 - 30 degrees.

9. Section 4C Safety. I am not sure as to exactly what standards met. This system is simpler to operate than only propane conversions and all propane flowing after the tank regulator is under 2 lbs. The carburetor modifications leave the carburetor no less safe or dependable than in its conventional form.

10. Section 5-B - Regulated Emissions and Fuel Economy. The testing we have accomplished have been mostly city driving or a combination of city and highway. To be sure of accuracy, we would install a special 5 gallon tank in the vehicle that is designed to use all fuel at any angle the vehicle is driving at and would carry 2 propane tanks.

To start a test, we would measure a desired amount of gasoline and then fill the tank with it and record the amount and mileage. The propane tank would be weighed on a large scale breaking the measurements down to grams and recorded also. At this point we would start the test. Driving would continue until the vehicle would run out of gasoline. The mileage was recorded and the propane tank was switched with the other then we would return to the shop. The propane tank was weighed and we would review our figures.

If there are any questions that I have not satisfactorily answered,please contact me and I will resolve them immediately.

Sincerely,

SCOTT VENNING

SV:d

ATTACHMENT G

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
ANN ARBOR, MICHIGAN 48105

OFFICE OF
AIR, NOISE AND RADIATION

December 15, 1982

Mr. Scott J. Venning
617 S. Busse Road
Mount Prospect, IL 60056

Dear Mr. Venning:

We received your letter of November 29. I am writing to confirm our understanding of the information supplied and claims made for the device and to discuss an appropriate plan for testing.

We are still unsure whether the model tested was a VCD or a V-3 but the test data are to apply to both. The claims for the efficiency of the device are based on these test data and are representative of the typical benefits achieved. You claim the device will:

1. Reduce the cost of fuel and the use of energy by 30% while idling,
2. Reduce the cost of fuel and the use of energy by between 14 and 23% in normal vehicle operation, and
3. Achieve these savings without a loss of power.

We also understand that the vehicle operates only on gasoline while cruising.

It appears that you are now ready to undertake testing at an independent laboratory. I have enclosed a copy of the basic test plan for 511 evaluations and a description of the test cycles. Since it is clear the device will affect emissions and fuel economy, the testing should include the complete Federal Test Procedure. However, either cold start or hot start testing would be acceptable to us. Test Plan A (no parameter adjustments required and no mileage accumulation required) is appropriate for your device. You may use the Test Sequence Code that you feel is most appropriate. Two vehicles will need to be tested.

By January 22, please let us know the test sequence you select, the laboratory you have selected, and the scheduled dates for your testing. Also, we are still awaiting your formal reply to our letter of November 29. The information requested in that letter is needed for our evaluation of your device. If you have any questions or require further information, please contact me at (313) 668-4299.

Sincerely,

Merrill W Korth

Merrill W. Korth
Device Evaluation Coordinator
Test and Evaluation Branch

Enclosure

cc: VCD File

"VCD" file

ATTACHMENT H

VCD FUEL SYSTEMS
617 S. BUSSE ROAD • MT. PROSPECT, IL 60056 • (312) 593-2184

February 22, 1983

Merrill W. Korth
EPA
Motor Vehicle Emission Laboratory
2565 Plymouth Road
Ann Arbor, Mi   48105

Dear Mr. Korth;

As per our phone conversation 2/22/83 I have sent you an estimate from EG&G Automotive Research, Inc.

I have also contacted Olson Engineering, and have been promised an estimate to be sent out by 2/24/83. One problem has come up at Olson Engineering, that until now I was not aware of. Jim Buxton at Olson seems to think that 1980 GM 229 V6 is not avalible in California. Could you please answer this question for me.

Olson Engineering is sending me a three part estimate:

1) VCD locates car with 229 V6

2) Olson Engineering locates 229 V6 vehicle out of state.

3) Use Buick 231 V6 (not acceptable for test)

I am also contacting a few other labs that may be more convenient. I will keep you posted on my progress and will forward the Olson Engineering estimate.

Sincerely,

Scott Venning

Scott Venning

file "VCD" Rec'd 3-7-83

MAC

VCD FUEL SYSTEMS

617 S. BUSSE ROAD • MT. PROSPECT, IL 60056 • (312) 593-2184

ATTACHMENT I

February 28, 1983

Merrill W. Korth
EPA
Motor Vehicle Emission Laboratory
2565 Plymouth Road
Ann Arbor, Mi. 48105

Dear Mr. Korth;

Enclosed is an estimate from Olson Engineering Inc. Would you please review this and let me know if this estimate meets your requirements.

I have also contacted the following and waiting for a reply.

Automotive Testing Laboratory
P.O. Box 289
East Liberty, Ohio 43319 (Myron Gallogly)

Ethyl Corporation
1600 West Eight Mile Road
Ferndale MI 48220 (Bill Brown)

I will be out of town 3/7/83 - 3/14/83 and will contact you when I return. I should have a reply from these labs at that time.

Sincerely,

Scott Venning

SCOTT VENNING
VCD FUEL SYSTEMS

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
ANN ARBOR, MICHIGAN 48105

ATTACHMENT J

March 16, 1983

OFFICE OF
AIR, NOISE AND RADIATION

Mr. Scott J. Venning
617 S. Busse Road
Mount Prospect, IL 60056

Dear Mr. Venning:

We received your letters of February 15 and 28 which requested our comments on the two test plans enclosed. I am writing to confirm our recent telephone conversation and to comment on these letters.

As I explained during our telephone conversation of March 1, the quotation from EG&G indicated that they only intended to perform a total of four LA-4s and four HFETs. However, we require duplicate test sequences, both before and after installation of the device, on a minimum of two vehicles. For a device for which both urban and highway benefits are claimed, the test sequence consists of a cold start FTP plus an HFET (or as a simplified alternative, a hot start LA-4 plus a HFET). Thus eight FTPs and eight HFETs are required. You planned to clarify this quote with EG&G. Please let us know the status of the test plan with this lab.

Your February 28 letter asked for our comments on the test plan from Olson Engineering. It appears adequate and provides the necessary number of tests. You also asked if the 1980 GM 229 CID engine was available in California. I thought it was not. I have checked further and it appears this engine is unavailable in California, at least through 1982.

You also stated that you were requesting quotes from Automotive Testing Laboratories and Ethyl Corporation. Please forward these test plans as soon as possible. Also, try to make your lab selection soon so that the testing can be completed by May 15. As a result of a recent ruling, we will have to start charging applicants for the testing performed by EPA. We are now in the process of implementing this directive but anticipate that those devices well along in the evaluation process will be exempt. In any case, it is in your interest to complete the testing as soon as possible.

By March 31, please let met know the test laboratory you have selected and the scheduled dates of your testing. If you have any questions or require further information, please contact me at (313) 668-4299.

Sincerely,

Merrill W Korth

Merrill W. Korth
Device Evaluation Coordinator
Test and Evaluation Branch

file "VCD"

VCD FUEL SYSTEMS

617 S. BUSSE ROAD • MT. PROSPECT, IL 60056 • (312) 593-2184

ATTACHMENT K

March 18, 1983

Merrill W. Korth
EPA
Motor Vehicle Emission Laboratory
2565 Plymouth Road
Ann Arbor, Mi. 48105

Dear Mr. Korth;

After looking over all four estimates, inclosed are estimates from Automotive Testing Laboratories, Inc. and Ethyl Corporation, I would like to test with;

Automotive Testing Laboratories Inc.
P.O. Box 289
East Liberty, Ohio 43319

There estimate looks fairly brief, but seems to contain all of the necessary steps.
Would you please check over there estimate and please advise me. The price is inline with the others and they are one of the closer labs.

Ethyl Corporations estimate is very confusing on steps:

1. Locate two vehicles - $1050

3., 4. Baseline tests not included.

I am also concerned with the additonal fee possibly required by EPA. We are very far along with our project and are tring to complete it as soon as possible.

Sincerely,

Scott Venning

Scott Venning - VCD

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
ANN ARBOR, MICHIGAN 48105

ATTACHMENT L

OFFICE OF
AIR, NOISE AND RADIATION

April 6, 1983

Mr. Scott J. Venning
617 S. Busse Road
Mount Prospect, IL 60056

Dear Mr. Venning:

We received your letter of March 18 which asked for our comment on the enclosed test plans and your proposed choice of labs.

Both ATL and Ethyl indicated that they would perform test plan/sequence A-1. This plan/sequence includes duplicate baseline and device tests using both a hot LA-4 and a HFET. Ethyl's proposal should provide the required testing on both vehicles. The ATL quote states "... running two (2) back to back baseline tests and two (2) back to back tests with your system installed." would be clearer if it continued with "... on each of the two test vehicles". You should check with ATL to ensure that their quote is for duplicate baseline and device tests on each of two vehicles. Also, ATL's proposal does not indicate that installation is included although this can be inferred from the narrative description of the sequence.

I can understand your concern about the possibility of being charged for subsequent EPA testing. As I previously stated, we anticipate those devices well along in the evaluation process will be exempt from these charges. However, in making any economic decisions you should consider the possibility of having to pay for testing at the EPA laboratory. In any case, it is in your interest to complete the testing as soon as possible.

By April 20, please let me know the scheduled dates of your testing and the test lab (presently ATL). If you have any questions or require further information, please contact me at (313) 668-4299.

Sincerely,

Merrill W Korth

Merrill W. Korth
Device Evaluation Coordinator
Test and Evaluation Branch

ATTACHMENT M

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
ANN ARBOR, MICHIGAN 48105

OFFICE OF
AIR, NOISE AND RADIATION

July 11, 1983

Mr. Scott J. Venning
617 S. Busse Road
Mount Prospect, IL 60056

Dear Mr. Venning:

This letter is to inform you of our intended course of action with respect to our evaluation of the "VCD" device.

As you know, we need test data which support the claims for the device. Based on our previous conversations and correspondence, we anticipated that the testing of the device would have been completed by now. However, it is now apparent that you are still in the process of developing your device and are presently unable to perform the necessary testing.

Because of the need to complete the evaluation in a timely manner, we are preparing our evaluation using the information currently available. We will consider the results of any further testing if we receive the data before the evaluation process is complete.

A notice in the Federal Register will summarize our findings and announce the availability of the final report. You will be sent a draft of both the report and the notice prior to their release. Ultimately, VCD will be added to our list as a device which has been evaluated. This list is distributed to interested parties upon request.

If you should decide to have the device evaluated in the future, a new application will be required. I will be glad to work with you at that time. If you have any questions regarding our course of action, please contact me at (313) 668-4299.

Sincerely,

Merrill W Korth

Merrill W. Korth
Device Evaluation Coordinator
Test and Evaluation Branch

Mailed July 25
Received July 28

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617 S. BUSSE ROAD • MT. PROSPECT, IL 60056 • (312) 593-2184

ATTACHMENT N

July 7, 1983

Merrill W. Korth
EPA
Motor Vehicle Emission Laboratory
2565 Plymouth Road
Ann Arbor, Mi 48105

Dear Mr. Korth;

Inclosed is the report from ATL. In the first test we had a stalling problem at off idle acceleration which we did not experience in normal driving. We felt that the additional load from the dyno might have made this problem apparent.

The vehicle #3387 stalled six times during the city portion of the testing. We would experience a stall after a complete stop and would hit a lean spot at off idle acceleration.
The results of vehicle #3387 in the city portion were as follows:

CT 19.054
CS 18.428 Baseline

CT 21.070
CS 23.985 Device

At this point we felt the stalling problem had to be corrected or the testing would be useless.
On the second vehicle #6362 we tried to richen the propane at idle to cover up the lean spot,but after running the vehicle we realised after two stalls the aditional propane was not helping and the driver started accelerating harder to get by the lean spot.
On the second test we used way to much propane at idle and realised when the testing started that it would not be favorable, because even if the gas mileage was high it was using to much propane.
The resuts of vehicle #6362 in the city portion were as follows;

CT 20.055
CS 19.265 Baseline

CT 23.835
CS 28.646 Device

I feel that we can work out the off idle stall and also still use less propane than in the first tests. WE are working on the project and are intending to go back to ATL for further testing.

Sincerely,